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VOLUME 20 NOVEMBER, 1946 NUMBER 6

CORALS FROM A LOWER PLIOCENE PATCH REEF IN CENTRAL JAVA

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ABSTRACT—Gunung Linggapadang is a small hill near Prupuk, Central Java. It consists of a fossil patch reef comparable to the reefs of the Bay of Batavia. Most of the corals collected in the surrounding marly beds are in an excellent state of preservation.

The fauna consists of about 70 species and is the largest suite of corals so far described from a Tertiary locality in the East Indies and 53 percent belong to still living species. Nine new species and varieties are described. The determination of the age of the fauna as Lower Pliocene is in agreement with other paleontological and geological data.

INTRODUCTION

GUNUNG LINGGAPADANG near Prupuk, Central Java, is a hill consisting of Tertiary reef limestone in the marly Tapak beds. The limestone itself is a fossil patch reef altered considerably by diagenetic processes. The corals are therefore in a bad state for identification. But specimens which originally tumbled down along the slope of the reef were imbedded in the muddy sediments accumulating on the floor of the sea. Most of these corals are excellently preserved and may be picked up in great quantities from the surroundings of the Prupuk reef. The original situation may be compared to the present growth of the patch reefs in the bay of Batavia and the Spermonde Archipelago (S. Celebes), the reefs growing on a muddy bottom aggraded by the accumulation of silt derived from rivers debouching on the neighboring coasts. Gradually the reefs are entirely buried in muddy sediments.

In 1928 I had the opportunity to visit the Prupuk reef and a large suite of corals was collected which was presented to the Mining Institute at Delft.

AGE OF FAUNA

The collection contains about 70 species. I have, however, not identified the species belonging to the genera Acropora and Porites, as these should be studied by specialists of these groups. Some other species are identified with a "confer." Consequently Nos. 1, 13, 14, 19, 24, 28, 42, 47, 54, 56, 59 and 61 of the accompanying table have to be left out of consideration. From the then remaining 49 species, 26 species, i.e. 53 percent are known from recent reefs in the Indo-Pacific.

This percentage shows the fauna to be older than the Pliocene Sonde and Upper Kalibeng beds which contain 70 percent of recent species. On the other hand it is younger than the Upper Miocene Tji Lanang beds (21 percent recent species) and even younger than the uppermost Miocene

TABLE I

Coral fauna of Prupuk, Java	Tertiary			
	f	g	h	
	Miocene		Pliocene	Recent
	Tji Lanang	Tji-sande	Sonde beds	
1. Seriatopora sp.		+		
2. Pocillopora jenkinsi Reuss	+		+	
3. Stylocoeniella minutissima (Gerth)				
4. Lithophyllia grandissima Felix		+		
5. Orbicella linggapadangensis Umbgrove, n. sp.				
6. Cyphastraea microphthalma (Lam.)			+	+
7. Cyphastraea chalcidicum (Forskal)				+
8. Leptastraea purpurea (Dana)			+	+
9. Galaxea fascicularis (Lin.)				+
10. Galaxea clavus (Dana)		+	+	+
11. Galaxea elegantissima Umbgrove, n. sp.		+		
12. Favia speciosa (Dana)			+	+
13. Favia sp.				
14. Favites cf. abdita (Ell. et Sol.)			+	(+)
15. Favites pentagona (Esp) var. tenuis Umbgrove n. var.		+		
16. Goniastrea retiformis (Lam.)			+	+
17. Goniastrea simplicitexta Umbgrove	+		+	
18. Metastraea aegyptorum E. & H.			+	+
19. Coeloria cf. daedalea Forsk.		+	+	(+)
20. Platygyra phrygia (Ell. et Sol.)			+	+
21. Hydnophora grandis Gardiner			+	+
22. Hydnophora tenella Quelch				+
23. Hydnophora solidior (Duncan)				
24. Hydnophora sp. (cf. microconos Lam.)				(+)
25. Merulina ampliata (Ell. et Sol.)	+	+	+	+
26. Lobophyllia corymbosa (Forsk.)		+	+	+
27. Lobophyllia costata (Dana)		+		+
28. Symphyllia cf. recta Dana			+	(+)
29. Echinopora gemmacea (Lam.) var. parva Umbgrove, n. var.				
30. Echinopora porosa Gerth				
31. Mycedium tubifex (Dana)				+
32. Oxyphyllia javana Umbgrove n. sp.				
33. Diploastraea heliopora (Lam.)		+	+	+
34. Fungia cyclolites Lam.			+	+
35. Fungia distorta Mich.				+
36. Fungia granulicostata Umbgrove n. sp.				
37. Fungia echinata Pallas			+	+
38. Fungia pseudoechinata Gerth		+		
39. Fungia subpaumotensis Umbgrove n. sp.				
40. Fungia concinna Verrill			+	+
41. Fungia inaequicostata Gerth			+	
42. Fungia sp.		+		
43. Herpolitha praecursor Umbgrove n. sp.				
44. Halomitra vetusta (Gerth)				
45. Pachyseris curvata Martin	+	+	+	
46. Cyathoseris lophiophora Felix		+	+	
47. Cyathoseris cf. crassilamellata Gerth		+		
48. Leptoseris hawaiiensis Vaughan				+
49. Pavona clavus (Dana)	+?		+	+
50. Pavonaraea irregularis Umbgrove n. sp.				
51. Coscinaraea columna (Dana)				+
52. Astreopora myriophthalma (Lam.)	+			+
53. Turbinaria crater (Pallas)				+
54. Turbinaria sp.				
55. Montipora dubiosa Gerth				
56. Acropora sp. div. (indet.)				
57. Goniopora tenuidens (Quelch)				+
58. Dictyaraea anomala Reuss	+		+	
59. Porites sp. div. (indet.)				
60. Alveopora polyacantha Reuss	+			
61. Alveopora sp.				
	8	15	24	26 (30)

reef limestone of Tjisande, which contains 46.6 percent of recent species. Judging from its coral fauna, the Prupuk reef, therefore, seems to be of Lower Pliocene age.

This conclusion is in agreement with other paleontological and geological data. On sheet 58 (Bumiajo, Ao. 1935) of the geological map of Java 1:100,000, the Prupuk reef is indicated by the name Gunung Linggopodo and the map shows this locality to belong to the so-called Tapak series, which is considered Lower Pliocene. Dr. Oostingh identified 31 molluscs from these beds and found 17 or 18 of them to be recent species (i.e., 55–59 percent). From another locality in the Bentasari basin, presumed to be of the same age he identified 65 species and found 38 or 39 of them to be recent (i.e., 58–60 percent). Finally, Mr. Ter Haar mentions the occurrence of remains of a mammal, *Merycopotamus nanus* Lydekker, in beds of a neighboring region of Central Java which, presumably, are of the same age. When dividing the Pliocene into two parts this species of *Merycopotamus* is considered to be characteristic of the lower part.

In the accompanying table a review is given of the coral fauna of Prupuk and a comparison is made with the Miocene faunas of Tji Lanang and Tjisande, the Pliocene fauna of the Upper Kalibeng and Sonde beds and the recent fauna of the Indo-Pacific.

SYSTEMATIC PALEONTOLOGY

Class ANTHOZOA

Subclass HEXACORALLA Haeckel

Order MADREPORARIA Verrill

Suborder MADREPORARIA IMPERFORATA

Family SERIATOPORIDAE Milne-Edwards and Haime

Genus SERIATOPORA Lamarck

SERIATOPORA sp.

Some small branchlets of *Seriatopora* show oval calices with directive septa *S. micrommata* Felix. The specimens are, however, not well enough preserved for identification of the species.

Genus POCILLOPORA Lamarck

POCILLOPORA JENKINSI Reuss.

1867. *Pocillopora jenkinsi* Reuss. p. 181, plate 3, fig. 10
1922. *Pocillopora jenkinsi* Reuss. Gerth, Java, p. 421
1923. *Pocillopora jenkinsi* Reuss. Gerth, Borneo, p. 94
1925. *Pocillopora jenkinsi* Reuss. Gerth, Nias, p. 32
1926. *Pocillopora jenkinsi* Reuss. Umbgrove, Sumatra, p. 39

According to Gerth this species is allied to the recent *P. molokensis* Vaughan.

Distribution—Upper Miocene (Tji Lanang Beds) of Java, Ngembak (Java); Miocene of E. Borneo; Plio-Pleistocene of Nias and Sumatra.

Family ASTROCOENIDAE Koby

Genus STYLOCOENIELLA Yabe and Sugiyama

STYLOCOENIELLA? MINUTISSIMA (Gerth)

1922. *Astrocoenia minutissima* Gerth. Java, p. 419
1923. *Astrocoenia minutissima* Gerth. Gerth, Borneo, p. 94, plate 7, fig. 2–4
1929. *Astrocoenia minutissima* Gerth. Umbgrove, Borneo, p. 61
1933. *Stylopora minutissima* Gerth. Gerth, Java, p. 38

The sole specimen from Gunung Linggapadang is a young colony incrusting a small branch of *Acropora*. Gerth described the massive growth type of older specimens from Borneo and Java, whereas I described a branched growth type from Borneo. A full description seems unnecessary, as Gerth's description of the calices applies to the present specimen. No coenenchyma occurs between the corallites as mentioned by Gerth (1933) in some Javanese specimens.

The corallites have six primary septa meeting the columella and six short secondaries. The septal margins and faces are distinctly granulated. Moreover Gerth (1933) described specimens with a finely granulated intercorallite area. These characters are typical for the genus *Stylocoeniella*. The occurrence of six pseudopali is not mentioned by Gerth, nor do they occur in the fossil from Linggapadang. I must point out, however, that pseudopali may be observed only in extremely well preserved fossils. Provisionally I am placing Gerth's species in the genus *Stylocoeniella*. The species seems closely allied to the recent species *S. hanzawai*.

Distribution.—Miocene (West-Progo beds and Rembang beds) of Java. Upper Miocene Miocene (Antjam beds) of Borneo.

Family LITHOPHYLLIDAE Gerth
Genus LITHOPHYLLIA Milne-Edwards and Haime
LITHOPHYLLIA GRANDISSIMA Felix

Two damaged specimens were described in my paper on the corals from Tjisande.

Distribution.—British Borneo from a locality of unknown age (Felix), East Borneo (Pliocene, Gerth) and Tjisande Java (Uppermost Miocene, Umbgrove).

Family ORBICELLIDAE Vaughan
Genus ORBICELLA Dana
ORBICELLA LINGGAPADANGENSIS
Umbgrove, n. sp.
Plate 77, figure 4

Corallum thin explanate and incrusting, 80 by 65 mm. Surface irregularly undulating. Corallites circular to slightly elliptical. Diameter of full-grown calices 7 to 12 mm., average 8 mm. Some calices projecting as much as 3 mm. Corallite walls not always fused as in places intercorallite spaces are present as in *Orbicella curta* Dana. In average-sized calices 22 to 30 septa occur, 10 to 14 reaching the columella. A cycle of very small septa alternate with the larger ones. Septa gradually slope towards centre of the calyx. Small paliform lobes preserved in some calices. Some septa, not all, continuous from one calyx to a neighboring one. Columella trabecular. Costae prominent on projecting calices. Reproduction takes place by intercalicular gemmation. Young calices distinctly projecting. In calices of 3.5 mm. diameter 12 septa occur, 6 reaching the very narrow columellar area.

Genus CYPHASTRAEA Milne-Edwards and Haime
CYPHASTREA MICROPHTHALMA (Lamarck)
Plate 77, figure 5

1913. *Cyphastrea microphthalma* (Lam.). Felix, Trinil, p. 347.
1922. *Cyphastrea microphthalma* (Lam.). Gerth, Java, p. 415
1923. *Cyphastrea microphthalma* (Lam.). Gerth, Borneo, p. 86

For synonyms and distribution of recent species see Umbgrove 1939, p. 25, 1940, p. 276, Yabe *et al.* 1936, p. 23 and Matthai 1914, p. 43.

A lone specimen from Gunung Linggapadang, forms a thin incrusting layer on a large fragment of *Cyathoseris lophiophora* Felix. Usually 10 septa, exceptionally 11, reach the columella.

Distribution.—Recent Indo-Pacific, Pliocene of Duku Pengkol, Java, and Sekurau, Borneo and Upper Miocene (Njalindungbeds) of Java.

CYPHASTREA CHALCIDICUM (Forskal)

1923. *Cyphastrea chalcidicum* (Forsk.). Gerth, Borneo, p. 86
1925. *Cyphastrea chlalcidicum* (Forsk.). Gerth, Nias, p. 29
1926. *Cyphastrea chlalcidicum* (Forsk.). Umbgrove, Sumatra, p. 37

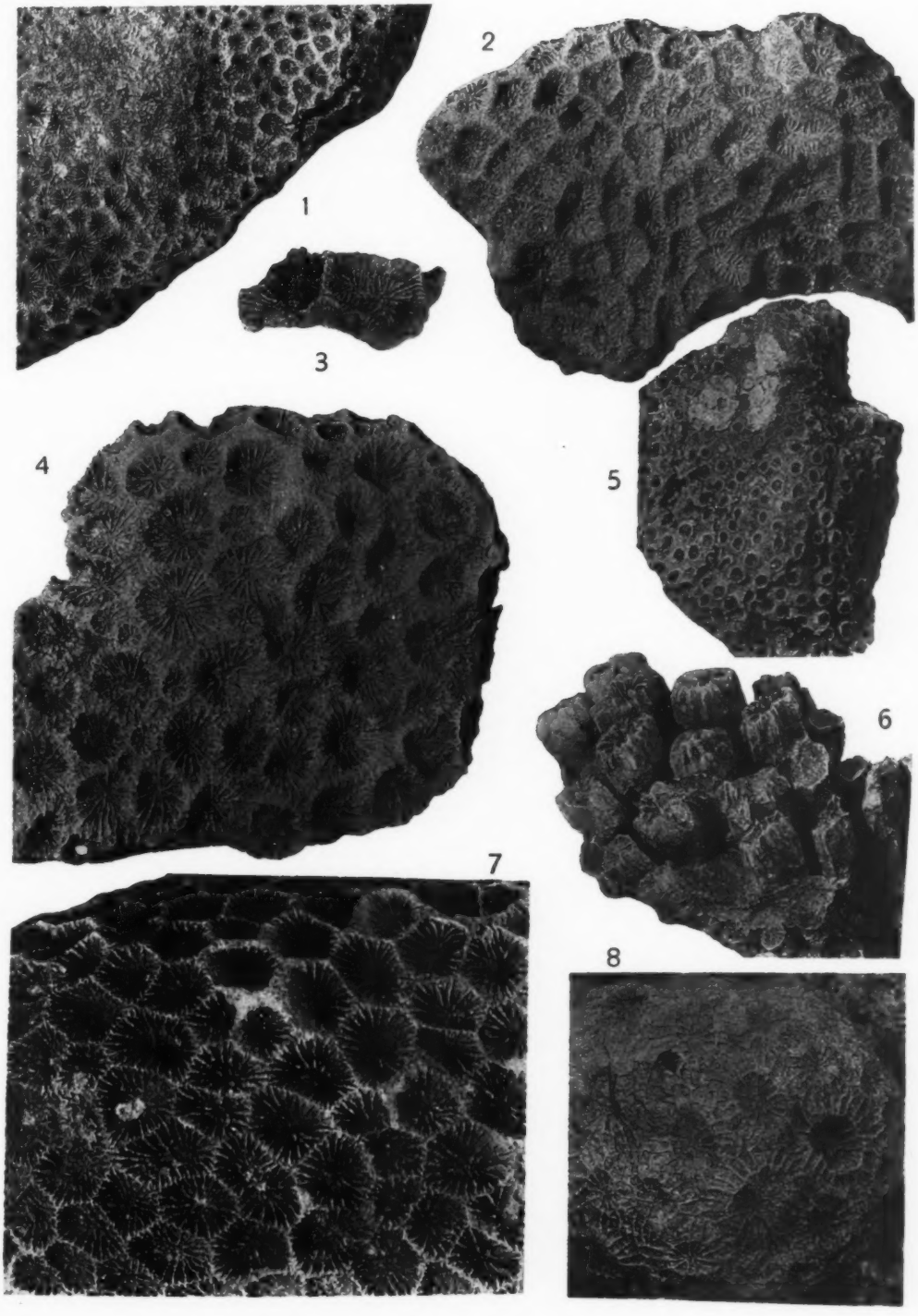
For synonyms and distribution of recent species see Umbgrove 1939, p. 26, 1940, p. 276, Yabe c.s. 1936, p. 24 and Matthai 1914, p. 41.

A common species from Gunung Linggapadang, but seldom with well-preserved calices. I studied 9 specimens. Corallum massive, forming irregular nodular growths. completely covered with scattered corallites. Calices crowded and evenly distributed with a diameter of 1½–2 mm., exsert up to 2 mm. Septa, costae and peritheca as in typical *C. chalcidicum*. *C. wanneri* Felix seems closely allied or identical.

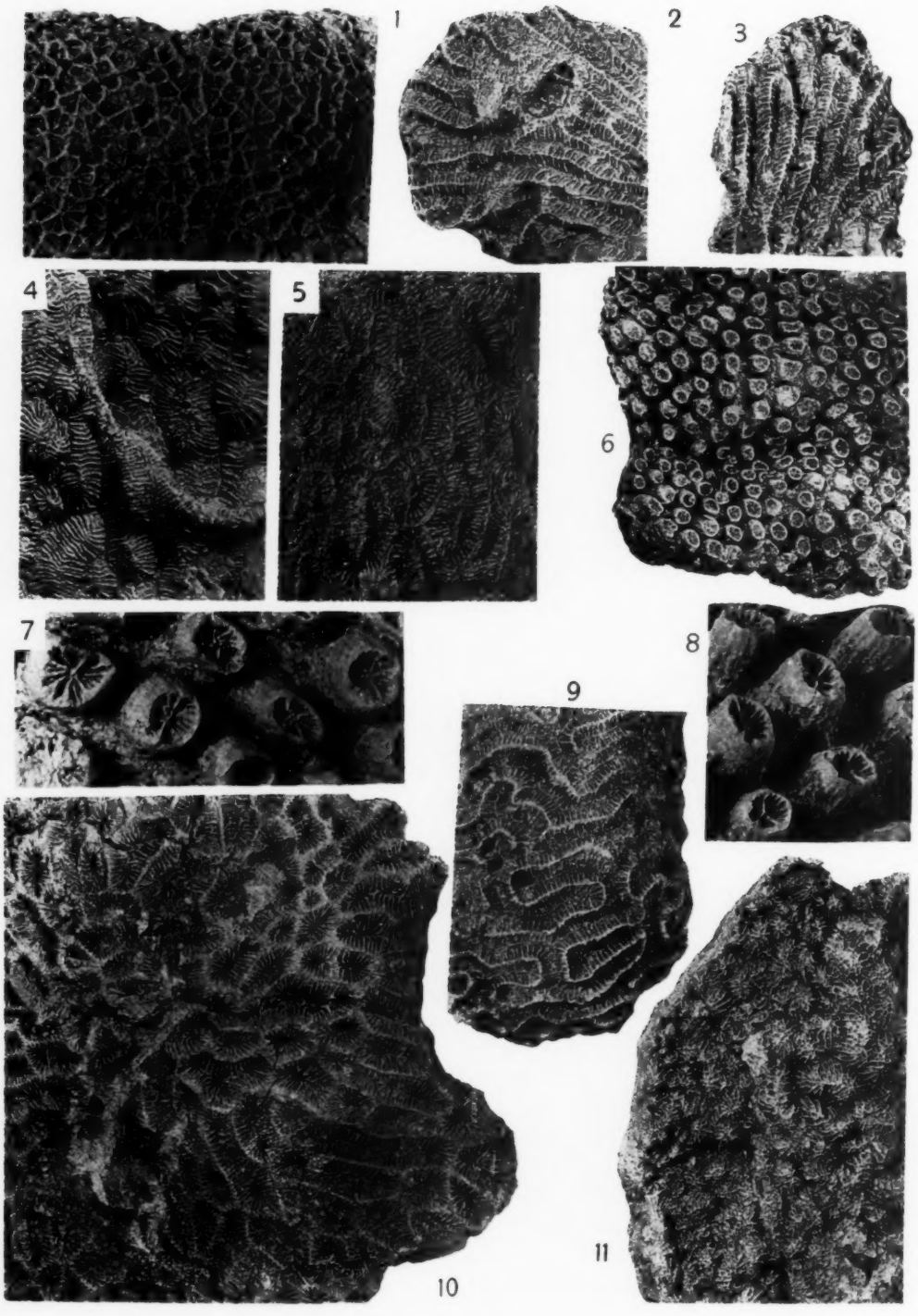
Distribution.—Recent Indo-Pacific, Pliocene of Sekurau, Borneo, Upper Neogene (Pliocene or even possibly Pleistocene) of Nias and Sumatra.

EXPLANATION OF PLATE 77
(All figures natural size unless otherwise indicated)

FIG. *1*—*Leptastraea purpurea* (Dana). (p. 525)
2—*Favia* sp. (p. 526)
3—*Favites cf. abdita* (Ellis and Solander). (p. 526)
4—*Orbicella linggapadangensis* ten Dam, n. sp. Holotype. (p. 524)
5—*Cyphastraea microphthalma* (Lamarck). (p. 524)
6—*Galaxea fascicularis* (Linn.). (p. 525)
7—*Favites pentagona* (Esper) var. *tenuis* Umbgrove, n. var., Syntype ×2. (p. 526)
8—*Favia speciosa* (Dana), grown on *Cyathoseris lophiophora* Felix. (p. 526)



Umbgrove, Lower Pliocene Corals



Umbgrove, Lower Pliocene Corals

Genus LEPTASTRAEA Milne-Edwards and Haime

LEPTASTREA PURPUREA (Dana)
Plate 77, figure 1

1922. *Leptastrea ehrenbergiana* Milne-Edwards and Haime, Gerth, Java, p. 348
1939. *Leptastrea purpurea* (Dana). Umbgrove, p. 26, (with synonyms) and 1940, p. 277

I refer three specimens to this species. One is a fragment (150 by 90 mm.) of a large colony encrusting *Cyathoseris lophiophora* Felix. Part of this specimen is figured. The granulation of the septal faces is distinct. The papillate columella is, however, preserved in a few calices only. The two other specimens have calices which closely resemble *L. ehrenbergiana* E. & H. as figured by Klunzinger in his plate 6, figure 3. The species was mentioned from the Pliocene of Java by Gerth.

Genus GALAXEA Oken

GALAXEA FASCICULARIS (Linné)
Plate 77, figure 6

1923. *Galaxea* cf. *fascicularis* (Linné), Gerth, Borneo, p. 89
1926. *Galaxea* cf. *fascicularis* (Linné), Umbgrove, Sumatra, p. 38

For other synonyms and recent distribution see Yabe, Sugiyama and Eguchi 936, p. 27, Umbgrove 1939, p. 27, and 1940, p. 277.

There is one specimen from Gunung Linggapadang. The calices are well preserved, the larger ones show five complete orders of septa, primaries thicker than secondaries, both exsert and meeting columella, tertiaries thin extending nearly to columella, fifth order septa very narrow. Columella poorly developed, deep. Costae sharp ridges along upper part of corallite wall. Diameter of circular corallites 5 mm., usually oval 3 by 6 mm., in large corallites 6 by 8 mm.

The species was described from the Miocene of Borneo and from the Holocene of Sumatra.

GALAXEA CLAVUS (Dana)

1924. *Galaxea clavus* (Dana). Umbgrove, Ceram, p. 6

For other synonyms see Umbgrove 1939, p. 27.

One specimen shows all details of calices and peritheca. All characters correspond in every respect with the description of *Galaxea musicalis* (Linné) as given by Matthai (1914, p. 63).

The species was described from the Plio-Pleistocene of Ceram and the uppermost Miocene of Java (Tjisande).

GALAXEA ELEGANTISSIMA Umbgrove, n. sp.
Plate 78, figures 6–8

The following description is from the best-preserved specimen, from Gunung Linggapadang, the holotype.

Corallites circular, oval or compressed, smaller than in other known species of the genus. Diameter 1 to 1.5 mm., oval ones up to 1.5 by 2 mm., projecting above peritheca up to 3 mm. Neighboring corallites 1 to 2 mm. apart.

Septa in four orders with rough sides. Primaries thicker than secondaries and slightly exsert, higher orders short to rudimentary. Columella very narrow formed by a few trabeculae from the septa. Costae low but distinct ridges, with indistinct granuliform projections. Perithecal vesicles small, closed on surface.

The largest specimen, from Tjisande, is a colony 160 by 150 mm. and 65 mm. high.

EXPLANATION OF PLATE 78
(All figures natural size unless otherwise indicated)

FIG. *1—Goniastraea simplicitexta* Umbgrove, ×2. (p. 527)
2, 3—Hydnophora tenella Quelch. (p. 529)
4, 5—Hydnophora solidior (Duncan), ×2. (p. 530)
6–8—Galaxea elegantissima Umbgrove, n. sp., *6*, Syntype natural size; *7, 8*, Syntypes ×4. (p. 525)
9—Platygyra phrygia (Ellis and Solander). (p. 528)
10—Metastraea aegyptorum Milne-Edwards and Haime. (p. 527)
11—Hydnophora grandis Gardiner. (p. 529)

Family FAVIIDAE Gregory
Genus FAVIA Oken
FAVIA SPECIOSA (Dana)
Plate 77, figure 8

1913. *Favia affinis* E. & H., Felix, Trinil, p. 349
1915. *Orbicella craterophora* Felix, Timor, p. 15, plate 38, fig. 9.
1915. *Favia cavernosa* (Forsk.) Felix, Timor, p. 20
1918. *Favia speciosa* (Dana), Vaughan, p. 103 (with synonymy)
1920. *Favia amplior* E. & H., Felix, Timor, p. 7
1920. *Favia okeni* M. Edw., Felix, Timor, p. 8
1925. *Favia speciosa* (Dana), Hoffmeister, p. 23
1925. *Favia speciosa* (Dana), Gerth, Nias, p. 27
1926. *Favia speciosa* (Dana), Umbgrove, p. 32
1927. *Favia speciosa* (Dana), Faustino, p. 130
1936. *Favia speciosa* (Dana), Yabe, Sugiyama and Eguchi, p. 28
1939. *Favia speciosa* (Dana), Umbgrove, p. 27
1940. *Favia speciosa* (Dana), Umbgrove, p. 277
1943. *Favia speciosa* (Dana), Umbgrove, p. 15

Two specimens. A small colony attached to a large folium of *Cyathoseris lophiophora* is figured. It belongs to the pandanus-type of *E. speciosa*.

The list of synonyms given above agrees mainly with Gerth's synonymy (Gerth 1931, p. 135). I added, however, *F. amplior* E. & H. of Felix and *Orbicella* & *Craterophora* Felix. The types of these corals are in the collections of the Mining Institute at Delft, where I restudied them and I have no hesitation in referring them to *F. speciosa*. Felix has given a good description of *Orbicella craterophora*; his illustration, however, is not a good one. To the description I add only that in the larger specimen some calices showing subequal fission occur.

Distribution.—Upper Neogene: Nias, Sumatra; Pliocene, Java; Pleistocene: Timor, Celebes; Recent.

FAVIA sp.
Plate 77, figure 2

The only specimen is a young colony extended as a thin lamina over a branched coral (probably *Acropora* sp). It is rather worn and a definite identification will be possible only when better preserved material from the same locality is available.

Dimensions 85 by 55 mm., and 15 mm. thick. Corallites polygonal, often distorted. Calicular walls slightly projecting. Calices up to 5×13 mm., averaging 4×7 mm. Septa thin, up to 30 in average-sized calices (50 in larger ones), 14 meet columella (25 in larger calices). Columella trabecular, poorly developed. Asexual reproduction by subequal fission.

Genus FAVITES Link
FAVITES cf. F. ABDITA (Ellis and Solander)
Plate 77, figure 3

For synonyms see Umbgrove 1939, p. 28 and 1940, p. 279.

As there is only one small fragment with imperfectly preserved septa from Gunung Linggapadang identification is hardly possible. However, shape and arrangement of the calices resemble *F. abdita*, especially the specimens figured by Matthai (1914) in plate 29, fig. 1 and plate 35, fig. 2.

Distribution: Neogene from Borneo, Pliocene from Java (Trinil), Plio-Pleistocene from Timor, Halmaheira and Christmas Island, recent in the Indo-Pacific.

FAVITES PENTAGONA
TENUIS Umbgrove, n. var.
Plate 77, figure 7

Corallum of massive growth-form, upper surface domed, horizontal diameter of larger specimen 110 by 70 mm.; height 85 mm. Corallites polygonal, separated by very narrow compact walls, which are acute on the upper edge. Calices up to 7 mm. in diameter, average 5 to 6 mm., depth 1.5 mm. or less.

Septa thin, with denticulate edges. Septal faces rough. In average-sized calices up to 12 septa reach the columella, each with a conspicuous paliform lobe. Between these a cycle of septa occurs which do not reach the columella and finally a cycle of very rudimentary septa is present. So, in a well developed calyx 12+12+24 septa may be counted. Septa slightly exsert over the intercorallite walls, usually alternating in adjacent corallites, exceptionally meeting at angles over the walls. Columella trabecular, not strongly developed 1 mm. or less in diameter. In worn specimens well developed endothecal dissepiments are visible. Reproduction in many calices by marginal fission occasionally subequal fission occurs.

The species seems to me closely allied to the recent species *F. pentagona* Esper (non *F. pentagona* Matthai, see Vaughan 1918, p. 112), which differs only by its much thicker vesicular walls and type of growth.

Genus GONIASTRAEA Edwards and Haime

GONIASTREA RETIFORMIS (Lamarck)

1908. *Goniastrea cerium* (Dana), Dollfuss. Celebes, p. 683
1912. *Goniastrea retiformis* (Lamarck). Felix, New Guinea, p. 437
1915. *Goniastrea retiformis* (Lamarck). Felix, Timor, p. 27
1922. *Goniastrea retiformis* (Lamarck). Umbgrove, Ceram, p. 8
1926. *Goniastrea retiformis* (Lamarck). Umbgrove, Sumatra, p. 34
1936. *Goniastrea retiformis* (Lamarck). Yabe, Sugiyama and Eguchi, p. 34, pl. 18, fig. 5, 6 (with synonymy)
1939. *Goniastrea retiformis* Umbgrove, p. 32
1940. *Goniastrea retiformis* Umbgrove, p. 281
1942. *Goniastrea retiformis* Umbgrove, p. 33, pl. XII, fig. 1; pl. XIII, fig. 4
1943. *Goniastrea retiformis* Umbgrove, p. 15

One specimen. It agrees with *G. parvistella* (Dana). Hoffmeister (1925, p. 26) pointed out that this form should be placed among the synonyms of *G. retiformis* (Lamarck). His statements are confirmed by my corals from the Togian Islands.

The species has a wide distribution in the Indo-Pacific area and has been described from the "Plio-Pleistocene" of Celebes (Dollfuss), New Guinea (Felix), Timor (Felix), Ceram (Umbgrove) and Sumatra (Umbgrove).

GONIASTRAEA SIMPLICITEXTA Umbgrove
Plate 78, figure 1

1942. *Goniastrea simplicitexta* Umbgrove, Buton, p. 35, pl. XII, fig. 4, pl. XIII, fig. 5
1943. *Goniastrea simplicitexta* Umbgrove, Sumba, p. 395

A full description of the species was given in my paper on the corals from Buton. I am illustrating here a well preserved specimen from Prupuk.

Distribution.—Upper Miocene (Upper Tertiary) of Java, Upper Pliocene of Java (Kalibeng beds), Upper Neogene or Pleistocene of New Guinea, Sumba and Buton.

Genus METASTRAEA Milne-Edwards and Haime

METASTRAEA AEGYPTORUM M-E. & H.
Plate 78, figure 10

1850. *Prionastrea? aegyptiaca* M-E. &. H. Ann. Sc. Nat. 3e ser., t. XII, p. 137
1857. *Metastraea aegyptorum* M-E. &. H. II, p. 425, pl. 29, fig. 1
1913. *Metastraea speciosa* Felix, Trinil, p. 353, pl. 25, fig. 2, 2a
1921. *Metastraea speciosa* Felix, Borneo, p. 34

Felix described *M. speciosa* from the Pliocene of Duku Pengkol (Java) and pointed out that his specimen strongly resembles the subrecent *M. aegyptorum* as described by Edwards and Haime. But he considered the Javanese specimen to be a separate species on account of the smaller number of septa and more diverging arrangement of the costae as compared to the coral from Egypt The characteristics of two specimens from Linggapadang, however, show in a convincing way that *M. aegyptorum* and *M. speciosa* must be considered synonyms. The supposed specific differences, mentioned by Felix, may be seen in one and the same specimen from Linggapadang, as shown in the following descriptions.

The specimen from Linggapadang, which is the best preserved is an applanate colony with slightly convex and undulating upper and lower surfaces, about 145 mm. in diameter. The maximum thickness in the central part is 25 mm.; it gradually thins towards the border, where the thickness diminishes to 1 mm.

The calices are scattered in an irregular manner but in a general way show a radial arrangement. This becomes more distinct in the distal region of the surface, due to the more frequent occurrence of calices which are elongated in a radial direction.

Calices polygonal, strongly differing in size, from young quadrangular calices of about 2 to 5 mm. diameter up to polygonal mature calices of 6×8 to 6×12 mm. (showing, however, two or more calicular centra) and strongly elongated calices with a maximum dimension of 5×30 mm.

Some of these elongated calices too show several calicular centres, demonstrating their formation by the fusion of several smaller calices which were serially arranged. Calices separated by thin nonperforated walls. Reproduction seems to have taken place mostly by intercalicular budding but sometimes by calicular fission as in *Favites*.

In small calices 12 septa reaching the centre alternate with 12 shorter to rudi-

mentary septa. In a larger single calyx of about 6×8 mm, 24 longer septa alternate with an equal number of rudimentary ones. In larger, strongly elongated marginal calices about 10 long and 10 rudimentary septa per centimeter may be counted. Up to about 64+64 septa in one calyx. The number of septa in *M. speciosa* and *M. aegyptorum* as shown by Felix's and E. Haime's illustrations, fall within this range of variability.

Septal margin with small irregular dentation and a small paliform lobe near the calicular centre.

Septa slightly thickened towards the wall. Mostly the larger septa of one calyx correspond to the rudimentary ones of neighboring calices. In worn places the rudimentary septa have disappeared. In well preserved calices the septa are continuous and slightly exsert over the walls. In worn parts each calyx appears to be surrounded by a complete wall, but the walls of neighboring calices fuse in their upper parts.

Vertical sections of the coral show small dissepiments at distances of about 1 mm.; dissepiments in upper part of the calyx vesicular, seen only in damaged calices. Columella a small trabecular structure.

Lower side of the coral shows radially arranged ridges diverging and bifurcating towards periphery separated by narrow valleys and covered by thin but distinct costae. Costae covered by irregular, blunt, but distinct granules. Costae sub-parallel to distinctly diverging; in places covered by thin concentrically arranged remains of an epitheca.

A second specimen is a more massive colony with a humpy surface, rejuvenated and overgrown on a calicular surface of the same colony. Although many calices are of the elongated shape, a radial arrangement of calices in such a typical manner as was described above is not to be seen. Most calices are slightly wider than in the applanate specimen and therefore still more resemble, both in shape and arrangement, the figured specimens of *M. aegyptorum* and *M. speciosa*, whereas on the average our first mentioned specimen has slightly narrower calices. Both types of calices, however, are present in the second specimen and this shows clearly that this characteristic too, is rather widely variable.

Genus Coeloria Milne Edwards and Haime

Coeloria cf. daedalea (Forskål)

Plate 79, figure 7

For synonymy see Umbgrove 1942, p. 36

One damaged and worn specimen from Tjisande has some meandering valleys (4 to 6 mm. wide) 9 to 11 septa in 1 cm. and a well developed columella. Perhaps one specimen from Gunung Linggapadang belongs to the same species, having some rather long valleys (3 to 5 mm. wide), very thin walls and 9 to 11 septa in one centimeter. The columella is only poorly developed and absent in places. The figure shows the best preserved part of this coral. The valleys are longer than in *C. equisepta* Gregory, which has more crowded septa and a well developed columella; in septal number and narrowness of the valleys it differs from *C. lamellina* (Ehrenberg). The present species should be further studied and described from more and better material from the same localities. I believe that it is a meandering type of *Coeloria* which may fall within the wide range of variation of *C. rustica* (Dana) as defined by Matthai (1928 Pl. VI, figs. 7 and 8). Perhaps even *C. equisepta* Gregory (also mentioned by Gerth and Felix) should be placed among its synonyms.

Distribution.—Pliocene from Borneo, Plio-Pleistocene from Ceram, Sumatra, Timor, Buton; Pleistocene, Celebes; Recent, Indo-Pacific.

Genus Platygyra Ehrenberg

Platygyra phrygia (Ellis and Solander)

Plate 78, figure 9

For synonyms see Matthai 1928, p. 112; Umbgrove 1939, p. 33 and 1940, p. 283; 1942, p. 37.

Two specimens from Gunung Linggapadang, one well preserved.

Distribution.—Recent, Indo-Pacific; Plio-Pleistocene, Christmas Island. I have also studied specimens from Upper Neogene (probably Pliocene) deposits of Java (coll. Geol. Survey, locality B. Solo near Padasmalang) and from the asphalt deposits of Buton.

Genus Hydnophora Fischer and Waldheim

1807. *Hydnophora* Fischer and Waldheim. Mus. Dimidoff III, p. 295

1886. *Monticulastraea* Duncan, Palaeontologica Indica, p. 87

Duncan in proposing the new genus *Monticulastraea* stated "This genus is a *Hydnophora* with a columella and with non-continuous septa" These characteristics are no solid base upon which to institute a new genus. Some of the recent species of *Hydnophora* have a well developed columella, and other recent species have septa which do not touch those on the other side of the axial space as in *H. tenella* Quelch and *H. tenella applanata* Umbgrove. Gerth (1923, p. 80) considered the thickening of the distal ends of the septa to be a generic characteristic of *Monticulastraea*. From a study of Matthai's photographs of recent *Hydnophora* one will be convinced that this character also is not distinctive. So I consider *Monticulastraea* a synonym of *Hydnophora*. *M. insignis* Duncan resembles *Hy. microconos*. However, a restudy of Duncan's type specimen would be needed to establish their possible identity. So far I can see *Hy. solidior* (Duncan) is a valid species, which up to now has been recorded from the Gaj series of Sind (Duncan) the Miocene of Borneo (Gerth 1923) and Sumatra (Umbgrove 1926) and which is not found on recent coral reefs. It seems to me that *M. solidior* Duncan and *M. inaequalis* belong to one and the same species. *M. elongata* Duncan may be a different species resembling recent *H. tenella* Quelch. I studied a fossil specimen from Sumba Island.

I revised the fossil specimens of this genus in the Geological Museum at Leyden. *Coeloria arborescens* Martin described by Martin and by Gerth from the Upper Miocene Tji Lanang beds of Java was provisionally placed among the synonyms of *Hydnophora exesa* (Pallas) by Gerth (1931). It belongs, however, to *Merulina*. The monticules are rounded and resemble those of *M. vaughani* Hoffmeister. There is, however, no lamen, the fragments being from angular branches. In some places calicular centres are well developed. As there are only three small fragments better material from the same locality should be obtained and described more fully. *Hydnophora astraeoides* Martin, known from the Upper Miocene Tji Lanang beds of Java, and from the Miocene of Borneo seems to be a valid species. *Hy. crassa* Martin from the Tji Lanang beds of Java was based on one small fragment, not well preserved. I do not know of any recent or fossil *Hydnophora* comparable to it except perhaps for *Monticulastraea inaequalis* Duncan. Felix described *H. contignatio* Forskål from the Pliocene of Java. It was placed among the synonyms of *H. exerta* (Pallas) by Gerth (1931). From Felix's description and his statement that it resembles Klunzinger's specimens, it is evident that it must be refered to *H. contignatio*.

Without a reexamination of Felix's specimen of *H. exesa* (Pallas) described from the Neogene of Borneo it is impossible to know what species he studied, because he mentions that his specimens resembles *H. exesa* as described by Bedot from Amboina. As Matthai (1928) pointed out, only the specimen figured on Bedot's pl. 25, figs. 123–126 is *H. exesa*, while figs. 127–129 are referable to *H. tenella* Quelch. So Felix's specimen may have been either *H. exesa* or *H. tenella*. I am doubtful whether the specimens described by Felix (1901) and by me (1929) from Borneo really belong to *H. tenella* Quelch.

HYDNOPHORA GRANDIS Gardiner
Plate 78, figure 11

For synonymy see Umbgrove 1939, p. 34.

I studied five fragments of thick explanate colonies. Three of these specimens are well preserved and are identical with the recent species as described by Gardiner (1904) and Matthai (1928). Felix reported this species from the Pliocene beds of Padas Malang, Java.

HYDNOPHORA TENELLA Quelch
Plate 78, figures 2, 3

1886. *Hydnophora tenella* Quelch, Sci. Rep. Challenger Exped. Zool., pl. V, fig. 8, 8a, p. 96
1904. *Hydnophora maldivensis* Gardiner, Fauna Maldive and Laccadive Archip. II, p. 765, pl. LX, fig. 22
1907. *Hydnophorella exesa* (pars), Bedot, Rev. Suisse Zool. XV, p. 199–201, pl. 25, fig. 127–129
?1901. *Hydnophora tenella* Quelch, Joh. Felix, Anth. von Borneo, Palaeont. v. Timor IX, p. 35
1923. *Hydnophora tenella* Quelch, Gerth, Samml. Geol. Reichs Mus. Leiden X, p. 79

1928. *Hydnophora tenella* Quelch. Matthai Cat. Madrep. Corals British Museum VII, p. 153, pl. 1, 14, 49
?1929. *Hydnophora* cf. *tenella* Quelch. Umbgrove, Wetenschapp. Mededeelingen 9, p. 60

Six specimens undoubtedly belong to this species. They are fragments of thin explanate colonies. The structure corresponds with the definition of the species as given by Matthai. Monticules are elongated up to 70 mm. being the total length as measured from the fragments. The upper margin of the ridges is rather sharp, only seldom and very locally rounded. Columella feebly developed mostly absent perhaps due to state of preservation of the fossils.

The species was described by Gerth from the Miocene (Kabasian river) of Borneo. I am doubtful whether the specimens described by Felix and by me from Borneo really belong to the present species.

HYDNOPHORA SOLIDIOR (Duncan)
Plate 78, figures 4, 5

1886. *Monticulastraea solidior* Duncan. Palaeontol. Indica, p. 88, pl. 26, fig. 5, 6
1923. *Monticulastraea solidior* Duncan. Gerth, Borneo, p. 80, pl. 5, fig. 4
1926. *Monticulastraea solidior* Duncan. Umbgrove, Sumatra, p. 35

The corallum grows in the form of an undulating lamen, 7 to 12 mm. thick. The non-calicinal surface is covered with crowded radiating costae. The collines are irregularly arranged in the central part of the colony, in the more distal parts they are more or less parallel and concentrically arranged. Collines short, unequal, sometimes curved. The septa seem to be subequal in the undamaged parts of the colony. In places where the specimen is damaged they appear alternately large and small. Especially in those parts the columella is very conspicuous, continuous around the collines and consists of two parallel lamellae separated by a very narrow groove. In places, but not in others, the distal parts of the septa are thickened. The septal ends fuse with the columella. The septa are united by a well developed endotheca, which is apparent in worn parts of the colony. The species was described from the Gaj beds of Sind, the Miocene of Borneo and Sumatra and has never been found on recent coral reefs.

HYDNOPHORA sp.
Plate 79, figure 2

Among the corals from Gunung Liggapadang is one small fragment of *Hydnophora* apparently belonging to a species which is different from those described above. It shows small conical monticules, irregularly distributed as in *H. microconos* (Lamarck). However, this fragment is not sufficiently well preserved for identification.

Genus MERULINA Ehrenberg
MERULINA AMPLIATA (Ellis and Solander)
Plate 79, figures 5, 6

1939. *Merulina ampliata* (Ellis and Solander). Umbgrove, p. 35
1940. *Merulina ampliata* (Ellis and Solander). Umbgrove, p. 285

Both the oral and the noncalicinal surfaces are well preserved in the specimens from Gunung Linggapadang which are fragments of large laminae showing in places low crests such as those typical for *M. ampliata*. The collines are rounded as in *M. vaughani* Van der Horst, which according to Matthai (1928) and the present author (1939) belongs among the synonyms of *M. ampliata* (Ellis and Solander). The fossil specimens correspond in every way with that recent species.

I studied Martin's type of *Coeloria arborescens* in the Geological Museum at Leyden. It belongs to the present species. Martin's and Gerth's specimens are from the upper Miocene of Java (Tji Lanang beds). Martin noted the resemblance of his specimens to *Hydnophora*.

Family MUSSIDAE Verrill
LOBOPHYLLIA CORYMBOSA (Forskål)

1913. *Mussa corymbosa* (Forskål). Joh. Felix, p. 343
1925. *Mussa* cf. *corymbosa* (Forskål). Gerth, p. 26
1928. *Lobophyllia corymbosa* (Forskål). Matthai, p. 210 (with synonymy)
1936. *Lobophyllia corymbosa* (Forskål). Yabe, Sugiyama and Eguchi, p. 43, pl. 33, fig. 1
1939. *Lobophyllia corymbosa* (Forskål). Umbgrove, p. 36
1940. *Lobophyllia corymbosa* (Forskål). Umbgrove, p. 287

A dozen fragments, some with well preserved calices from Gunung Linggapadang,

and many less well preserved specimens from Tjisande. This species, which is living in the East Indian seas, was reported by Felix from the Pliocene of Duku Pengkol (Java) and by Gerth from the Upper Neogene of Nias.

LOBOPHYLLIA COSTATA (Dana)

1925. *Mussa* cf. *distans* Klunzinger. Gerth, p. 26
1928. *Lobophyllia costata* (Dana). Matthai, p. 216 (with synonymy)
1936. *Lobophyllia costata* (Dana). Yabe, Sugiyama and Eguchi, p. 43, pl. 31, fig. 3
1939. *Lobophyllia costata* (Dana). Umbgrove, p. 37
1940. *Lobophyllia costata* (Dana). Umbgrove, p. 287

Two specimens from Gunung Linggapadang, one large and well preserved and one much abraded specimen from Tjisande. Gerth reported this species from the Upper Neogene of Nias. Andrews studied either the same species or the closely allied *L. hemprichii* (= *echinata* E. & H.) from the Plio-Pleistocene of Christmas Island. The species hs a wide recent distribution in the Indo-Pacific.

Genus SYMPHYLLIA Milne-Edwards and Haime

SYMPHYLLIA cf. S. RECTA Dana

Plate 79, figure 3

For synonymy see Umbgrove 1940, p. 288

Only one small fragment. The valleys are rather narrow not exceeding 12 mm. The specimen is rather worn and specific identification is impossible, without better specimens but it probably belongs to *S. recta* or an allied species.

Distribution.—Pliocene Java (Sondé), recent Indo-Pacific.

Family ECHINOPORIDAE Verrill

Genus ECHINOPORA Lamarck

ECHINOPORA GEMMACEA PARVA Umbgrove, n. var.

Plate 79, figure 3

A common species in the Linggapadang limestone is an *Echinopora*, which I consider closely allied to the recent Indo-Pacific species *E. gemmacea* (Lamarck) as it has strongly projecting calices and a vesicular peritheca. The fossil specimens differ by the smaller diameter of their calices and their smaller number of septa. I studied about thirty fragments. No corallites have developed on the lower side of the lamen which is covered with very fine low and flat costae, about 24 in one cm. Thickness of lamen up to 5 mm. Peritheca vesicular in places, with distinct ridges connecting septocostae. Spines usually absent; when present very low and blunt. Corallites circular, projecting vertically or obliquely up to 5 mm., usually about 3 mm.

Diameter of calices up to 3 mm., usually about 2 mm.

Septa in three orders, primaries and secondaries subequal, tertiaries rudimentary; occasionally a few quaternaries are developed. Columella thin, trabecular, not preserved in most calices.

E. crassatina, described by Gerth from the Miocene (?) of Ngembak, Java, and from the Upper Miocene of Borneo is closely allied but has calices of larger diameter and somewhat different shape. In my opinion *E. crassatina* also is a variety of *E. gemmacea* Lamarck.

ECHINOPORA POROSA Gerth

Plate 80, figure 7

1925. *Echinopora porosa* Gerth, Nias, p. 31, pl. 5, fig. 3

The description of the species by Gerth is entirely applicable to a single fragment from Gunung Liggapadang, which I compared with Gerth's types in the Leyden Museum.

Distribution.—Neogene (Pliocene) of Nias.

Genus MYCEDIUM Oken

MYCEDIUM TUBIFEX (Dana)

Plate 79, figure 1

1924. *Mycedium* cf. *tubifex* (Dana). Umbgrove, Ceram, p. 14, pl. 2, figs. 6 and 7
1936. *Mycedium tubifex* (Dana). Yabe, Sugiyama and Eguchi, p. 49, pl. 37, figs. 3, 4 (with synonymy)
1939. *Nycedium tubifex* (Dana). Umbgrove, p. 40, pl. IX, figs. 1, 2

From Gunung Linggapadang I collected one coral specimen with a very irregularly undulating surface; diameter 150 by 140 mm., and up to 45 mm. thick. The upper calicular layer is grown over several older layers of the same species. The lower surface is much worn. The calices are scattered in

an irregular manner and are sunken but with slightly elevated margins. Diameter of calices 4–7 mm., usually about 6 mm. and 12 to 14 septocostae radiate from a calice, 6 to 9 septa reaching the columella. The columella is a very thin trabecular structure; a few papillae may occur on its surface in a few calices. Septocostae subequal, smooth, sharp-edged ridges, 10 to 12 in one cm. Cross sections of the laminae show a dissepimental structure.

Genus OXYPHYLLIA Yabe and Eguchi
OXYPHYLLIA JAVANA Umbgrove, n. sp.
Plate 80, figure 2

The holotype is a rectangular fragment 96 mm. long, 70 mm. broad, 10 to 20 mm. thick with strong dissepimental structure. The noncalicular surface is covered with thin but prominent longitudinal costae, up to 12 in one cm., alternately thicker and thinner. In unworn places they show small blunt granuliform dentations. Upper surface with irregularly scattered calices which are circular (exceptionally elliptical), shallow, with pseudo-walls. Most calices prominent, inclined; the proximal parts of the calicular margin slightly elevated. Diameter of calices 4 to 8 mm., usually about 5 mm. From full-grown calices 12 to 18 septo-costae radiate and up to 12 septa reach calicular centre. Septo-costae form prominent subequal ridges, without dentations or granulae and with only a sharp tooth-like elevation on the calicular margin. Columella small, trabecular.

The pseudo-walls of the calices resemble those of *O. aspera* (Ellis and Solander), which differs by the larger diameter of its calices, the stronger developed columella and dentated septo-costae. The smoothness of the septa resembles some species of *Mycedium*. On account of the shape of the calices I refer this species, however, to the genus *Oxyphyllia*.

Family OULASTREIDAE Vaughan
Genus DIPLOASTRAEA Matthai
DIPLOASTRAEA HELIOPORA (Lamarck)

Along with specimens from the Upper Kalibeng beds of Java, Tjisande and the Prupuk reef, I identified this well known coral from the following localities: (1) North Sumba, Laonatang, on the summit of a hill along the Kanata river (coll. H. ten Kate No. 962, 1891, Geolog. Instit., Utrecht); (2) North Coast of Flores, Nanga Reo (coll. A. Wichmann, No. 684, 1890, Geol. Instit. Utrecht); (3) Northern peninsula of Amboina (coll. A. Wichmann No. 21 Jan. 4, 1903, Geol. Instit. Utrecht); (4) S. Celebes, Bantimurung (coll. A. Wichmann No. 535, 1890); (5) Eurekang, Celebes (loc. 231); (6) Manokwari, New Guinea (coll. van Nouhuys, Mining Instit., Delft;) (7) Oi feko near Kupang Timor (col. A. Wichmann 703 No. 819, 1890, Geol. Instit. Utrecht); (8) Rotti, S. coast of Nusa Manuk (coll. A. Wichmann 896 No. 970, 1890, Geolog. Instit. Utrecht); (9) Celebes Donggala (see Umbgrove, Celebes 1943); (10) S. W. point of Java, Straits Sunda (See Umbgrove Wetensch. Mededeel, No. 7, 1928, and Proc. Kon. Akad. v. Wetensch. Amsterdam 34, 1931, p. 487). Other localities in Java Nias Sumatra, Ceram, Timor and New Guinea are mentioned by Gerth (193, p. 139).

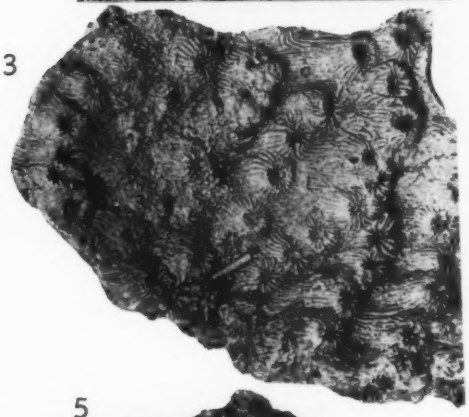
Distribution: The species has a wide distribution in the East Indies, from Miocene to Recent time.

MADREPORARIA FUNGIDA
Family FUNGIDAE Dana
Genus FUNGIA Lamarck

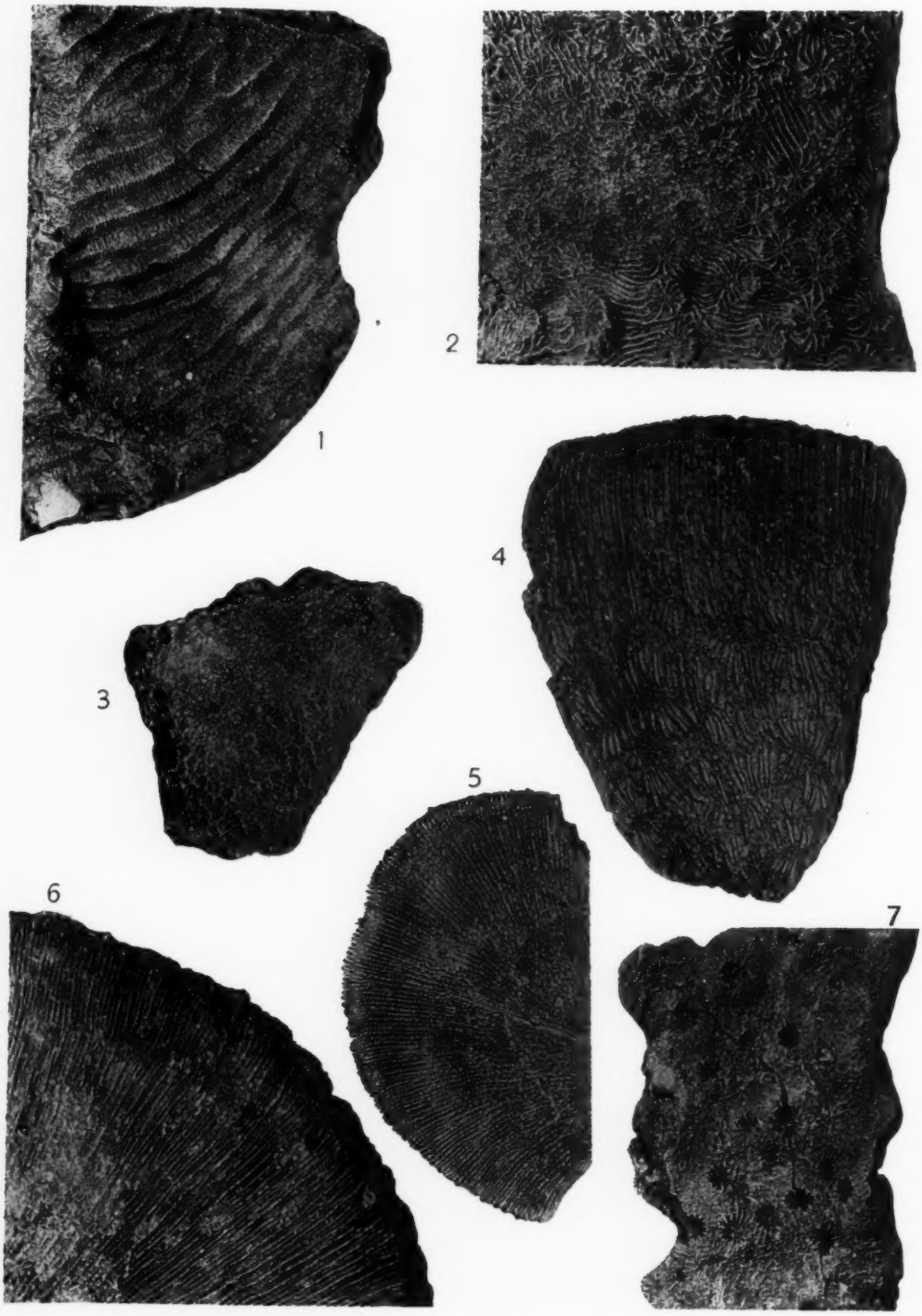
Gerth described *Fungia* cf. *scabra* Döderlein and reported *F.* cf. *actiniformis* Döderlein from Gunung Linggapadang. I failed to find his specimens in the collection of the Geological Museum at Leyden. Therefore, these species are not enumerated in Table I.

EXPLANATION OF PLATE 79
(All figures natural size unless otherwise indicated)

FIG. *1—Mycedium tubifex* (Dana), ×1½. (p. 531)
2—Hydnophora sp., cf. *mcrioconus* Lamarck. (p. 530)
3—Echinopora gemmacea (Lamarck) var. *parva*, ten Dam n. var., Holotype. (p. 531)
4—Symphyllia cf. *recta* Dana. (p. 531)
5, 6—Merulina ampliata (Ellis and Solander), *5*, upper surface: *6*, lower surface. (p. 530)
7—Coeloria cf. daedalea Forskål. (p. 528)



Umbgrove, Lower Pliocene Corals



Umbgrove, Lower Pliocene Corals

FUNGI CYCLOLITES Lamarck

For synonyms see Döderlein 1902 and Gerth 1931, p. 139.

I collected one specimen only, which is rather badly worn. However, after careful comparison with well preserved material, I do not hesitate in identifying it with the recent species *F. cyclolites*.

Distribution: Miocene, Borneo; Pliocene, Java, Sumatra; Plio-Pleistocene, Timor; Pleistocene, Borneo, Talaud; Recent, Indo-pacific.

FUNGIA DISTORTA Michelin
Plate 81, figures 3, and 4

Fungia distorta Michelin. Döderlein 1902 (older synonyms)
Fungia distorta Michelin. Gardiner 1905
Fungia distora Michelin. Boschma 1923
Fungia distorta Michelin. Boschma 1925
Fungia distorta Mechelin. Faustino 1927
Fungia distorta Mechelin. Boschma 1929

Eight specimens studied. Upper surface of corallum slightly convex gradually increasing in thickness towards the centre. Marginal region 6 to 8 mm., central region 14–19 mm. thick in specimens having a diameter of 70–75 mm. Lower surface of the disc flat or slightly concave. Wall imperforate. Near the edge of the disc costae subequal, towards the centre they diminish in strength and become unequal only those of the first cycles reaching the centre. Septal edges blunt, those of the higher cycles suddenly decreasing in height. The specimens from Java correspond in every respect to the description by Döderlein (1902) and Boschma (1923). The only difference is the indistinctness of the granulations on the septa in the Javanese specimens, which I ascribe to their conditions of preservation and fossilization.

Distribution—Recent, Indo-pacific.

FUNGIA GRANULICOSTATA Umbgrove, n. sp.
Plate 80, figure 6.

The holotype is a circular disc of about 200 mm. diameter, with a lobate margin. Only a fragment is preserved. Thickness of the disc in the centre, 45 mm. gradually diminishing towards the margin. Aboral surface imperforate, covered with subequal costae, which are slightly prominent lamellae. The costae extending from the margin of the disc to the centre bear small but distinct non-elongated granuliform spines (16–20 per mm.). At the margin of the aboral surface the costae of the lower cycles correspond with slightly thicker and higher septa and are distinctly more prominent than a few (generally 3) costae of higher cycles between them which do not reach the centre of the disc. Lower surface nearly flat, slightly convex, especially along the margin and in the central area. Oral surface slightly convex. Its greater part is badly damaged; thus the nature of the septal edges cannot be determined. Septa perforated and finely granulated; granules arranged in horizontal rows. The axial fossa is not preserved. The combination of characters shown by this large specimen is different from any living or fossil *Fungia* that has been described. It might be compared to forms like *F. costulata* Ortmann but before we can determine its relationships better material must be obtained in which the septal edges are preserved.

FUNGIA ECHINATA Pallas

For synonymy see Umbgrove 1926 and 1940.

Only one fragment of the border of a large and strongly elongated specimen is available. It shape, the strong granulation of the septa and the big rough spines on the lower surface, though in general badly worn,

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EXPLANATION OF PLATE 80
(All figures natural size unless otherwise indicated)

FIG. *1*—*Pachyseris curvata* Martin, ×9/10. (p. 536)
2—*Oxyphyllia javana* Umbgrove, n. sp. Holotype. (p. 532)
3—*Alveopora polyacantha* Reuss (p. 540)
4—*Halomitra vetusta* (Gerth) (p. 535)
5—*Fungia subpaumotensis* Umbgrove, n. sp., Holotype. (p. 534)
6—*Fungia granulicostata* Umbgrove, n. sp., Holotype. (p. 533)
7—*Echinopora porosa* Gerth, ×5/4. (p. 531)

are characteristic of *F. echinata*. Along the margin of the disc even the big teeth on the septa are preserved.

Comparing this fragment with a collection of recent specimens of this species, it is obvious that the original dimensions of the fossil must have been at least 250 mm. in length and 150 mm. in breadth.

It cannot be ascertained whether the corallum corresponded exactly with the recent species, or with the "forma neogenica" as described by Gerth from Borneo (1923, p. 101) because the axial fossa is not preserved. In order to settle this point we must wait for better preserved specimens.

A badly worn and damaged specimen from the Tjisande limestone may perhaps belong to this species. It is a fragment of an elongated disc, which along its longer axis measured at least 230 mm. Identification of this specimen is impossible.

Distribution—Plio-Pleistocene, Sumatra; Recent: Indo-Pacific.

FUNGIA cf. PSEUDOECHINATA Gerth

Gerth 1925, p. 40, Taf. 6, figs. 2, 2a

One fragmentary specimen from Tjisande is referred to this species. The lower surface is hidden by adhering rock material.

From Prupuk only one damaged and much worn specimen was obtained which probably belongs to this species but its poor preservation makes safe identification impossible.

FUNGIA SUBPAUMOTENSIS Umbgrove, n. sp.
Plate 80, figure 5

For a full description of this species more material and complete specimens should be available. The holotype, a fragmentary specimen, shows, however, such characteristic features that its assignment to the *scutaria* group is beyond doubt. It resembles in many respects *F. paumotensis* Stuchb. Perhaps with the aid of more complete specimens it will be possible to identify the fossil with either that species or with *F. moluccensis* Van der Horst which is closedly allied, as demonstrated by Boschma (1925, p. 211). The specimen from Prupuk is a fragment of an elliptical disc. Its lower surface is nearly flat; only along the margin of the disc is a narrow rim prominent. The costae are equally developed, slightly lamellar and covered with small spines as in *F. paumotensis* and in some specimens of *F. moluccensis* and *F. sibogae*. The disc is low in its marginal part, only 6 mm. high. I am not sure whether the central part of the oval surface was elevated around the axial fossa but this seem to be faintly indicated. If so it would resemble *F. moluccensis*. The septa are mostly worn off but along the marginal part of the oral surface it seems to me that the finely dentated septal edges are preserved for a short distance.

FUNGIA CONCINNA Verrill
Plate 81, figures 5, 6

For synonyms see Thiel 1932

Two specimens, Gunung Linggapadang near Prupuk (Java). Both specimens are rather well preserved. The larger fragment is half of a large disc, having a diameter of 135 mm. Lower surface nearly flat, slightly concave. Wall imperforate. Costae diminishing in strength towards the centre. Central part of the disc granulated. First cycle of costae prominent near the edge of the disc, bearing blunt and finely granulated spines. Costae of the other cycles lower and rapidly diminishing in size, not reaching the central part of the disc and bearing spines of the same type although less strongly developed. The upper surface of the disc is rather badly damaged. Locally the septal edges are preserved, showing distinct teeth. Septa finely granulated. Granules locally arranged in rows perpendicular to the septal edges.

In the smaller fragment, which is from another specimen, the costae are not so unequal and the costal spines are more slender and finely granulated.

I have no hesitation in identifying these fragmental fossils with the widely distributed recent species *F. concinna* as I compared my specimens with a large suite of recent material.

Distribution.—Recent, Indo-Pacific. Fossil, Plio-Pleistocene (Ceram) and Plesitocene or younger (Talaud).

FUNGIA INAEQUICOSTATA Gerth
Plate 81, figure 8

Gerth 1925, p. 41, Taf. 6, figs. 1–1a

I compared my material with Gerth's type specimens in the Leyden Museum, the lower surfaces of which are rather in-

crusted. Therefore, I am figuring a new specimen, showing clearly the strongly developed costae with smaller ones between. I do not agree with Gerth that the species is a *Cycloseris*, as the well developed spines on the costae and the teeth on the septa prove the coral not to belong to the *patella* group. The strongly developed costae of the first cycle bear very distinct rough spines, the thinner costae of the other cycles possess smaller but distinct blunt spines which occur also in the central part of the disc. Thus this *Fungia* belongs to the *repanda* group and it must be closely allied to *F. concinna* Verrill, a well known recent species, which has been found in Neogene strata at the Prupuk locality. The diameter of the specimens studied ranges from 73 up to 92 mm.

In my specimens, as in those described by Gerth, the septa are not well preserved. It may, however, be seen that they are crowded with fine granules locally arranged in rows perpendicular to the edges of the septa, which bear distinct teeth (8 per centimeter). In all specimens studied the theca is imporforate.

FUNGIA sp. 1

Among the fossils from Prupuk one specimen of *Fungia* is distinctly different from the species described above. On account of the bad state of preservation I cannot, however, give a full description and a comparison with recent material cannot be made. The specimen is a round disc 58 mm. diameter. The lower surface is concave except for the central part which moreover shows a distinct scar of attachment. Wall imperforate; costae subequal, reaching the central part of the disc. Septa of the first cycle slightly thicker than the many very thin septa of the other cycles. Upper surface convex, gradually increasing in height from the rather sharp edge of the disc to the centre. Maximum height of corallum, in the centre, 16 mm. A second specimen from Tjisande apparently belonging to the same species has a diameter of 80 mm. Its lower surface is only slightly concave.

FUNGIA [HERPOLITHA?] PRAECURSOR
Umbgrove, n. sp.
Plate 81, figure 1

I am figuring the oral surface of the holotype, a fungid coral, which does not belong to any of the species described above. Disc flat, up to 5 mm. thick, elongate, sharp-edged. Septa gently curving towards the long axial fossa.

The septal edges bear small blunt, rough dentations. Septal faces crowded with fine granulations.

Septa and costae alternating stronger and weaker, 15 to 17 in one cm.

The lower surface is so badly worn, that the character of the costae can be studied only in one place along the margin of the disc. There the costae bear small rough granuliform dentations of the same kind as occur on the septal edges.

These characters are so different from other *Fungia* having a long axial fossa, that I feel justified in considering it a new species.

The character of the small costal spines resembles *Herpolitha simplex* Gardiner, which is, however, differentiated by the stronger dentations of the septa.

Genus HALOMITRA Dana
HALOMITRA VETUSTA (Gerth)
Plate 80, figure 4

1925. *Döderleinia vetusta* Gerth, p. 39, Taf. 6, fig. 3, 3a

Among the fungid corals in my collection is only one small fragment of a large specimen belonging to this interesting species. Although the oral surface is much worn I am figuring it as it shows the inner structure of the secondary calicles and the synapticulae between the septa. The thickness of this fragment is 23 mm., gradually diminishing towards the rather sharp edge of the disc. The upper surface of this specimen is strongly convex; the aboral surface equally concave and imperforate. Costae thin, slightly lamelliform and subequal. I agree with Gerth that the species differs from the recent *H. robusta* (Quelch) by its having no spines on the aboral surface. *Doederleinia* Gardiner must be placed among the synonyms of *Halomitra* Dana (see Boschma 1925 and Umbgrove 1900).

I have examined "*Halomitra tiara* Verrill" as identified by Felix (1923, p. 13) from a Plio-Pleistocene reef-limestone in Timor, the specimen being in the collections of the Mining Institute at Delft. It is only a fragment of the upper surface of a *Halomitra*.

Although undoubtedly belonging to this genus, it is insufficiently preserved; the structure of its lower surface cannot be seen and a specific identification is absolutely impossible.

Family AGARICIIDAE Verrill
Genus PACHYSERIS Milne-Edwards and Haime

From Neogene deposits in the East Indies 13 species of *Pachyseris* have been described. As much as possible I have reviewed the type-specimens. Some of the species were described on fragmentary and badly preserved specimens. In my opinion 8 species are well defined; 6 of these are known only from Neogene deposits. Two other species are still living, *P. speciosa* (Dana) and *P. valenciennesii* M.-E. & H. Both were described by Gerth from the Neogene (probably Pliocene) of Nias. I am not convinced that *P. speciosa* as described by him from the Miocene of Borneo, belongs to this species, for the specimen has rather broad valleys and rounded collines. *P. tenuisepta* Felix from the Pliocene of New Guinea probably belongs to a Recent species with narrow valleys, either *P. speciosa* or *P. laevicollis* (Dana). Apparently the type specimen of *P. laevicollis* from Prupuk mentioned by Gerth is lost; I looked in vain for it is the Geological Institute at Leiden where it should be preserved. *Pachyseri* (*Comoseris*) *javana* Gerth belongs to the new genus *Pavonaraea*, described below.

The following is a review of the six Neogene species in alphabetic order.

(1) *P. affinis* Duncan. Colline broadly rounded and with many ramifications and meanders, but on the whole radially arranged in the same way as the costae on the lower side. Septa unequal, 14 to 20 in 5 mm. Columella lamellate. Valleys 3–10 mm. wide (Syn. probably *P. excavata* Duncan).

(2) *P. compacta* Umbgrove. Collines mostly acute. Septa equal, 13 or 14 in 5 mm. Valleys 2 to 3 mm. wide. Columella lamellate. Growth-shape compact.

(3) *P. curvata* Martin. Collines generally sharpedged, arranged concentrically. Costae radially arranged. Septa subequal and provided with small and acute dentations. Septa 14 to 16 in 5 mm. Columella lamellate, valleys 4 to 5 mm. wide. (Synonyms: *P. cristata* Martin, *P. laticollis* Martin, *P. vandyki* Gerth, *P.* cf. *torresiana* Gerth.)

(4) *P. denticulata* Gerth. Collines rounded. Septa equal and with coarse dentations Septa 10 in 5 mm. Valleys 4 to 6 mm. wide. Columella rudimentary.

(5) *P. distans* Gerth. Collines rounded. Septa equal. Septa 6 in 5 mm. Valleys 10 mm. wide. No columella.

(6) *P. murchisoni* Haime. Collines rounded, septa unequal, 8 in 5 mm. Valleys 10 mm. wide. Columella lamellate.

PACHYSERIS CURVATA Martin
Plate 80, figure 1

1880. *Pachyseris curvata* K. Martin, Tertiairschichten auf Java, p. 145, Taf. 25, fig. 8, Taf. 26, fig. 7
1880. *Pachyseris cristata* K. Martin, idem, p. 415, Taf. 25, fig. 9, Taf. 26, fig. 8
1880. *Pachyseris laticollis* K. Martin, idem, p. 146, Taf. 25, fig. 10
1913. *Pachyseris cristata* W. D. Smith, The Philippine Journ. of Science VIII, p. 389
1922. *Pachyseris van dijki* Gerth, Samml. Geol. Reichsmus. Leiden N. Folge I. 2., p. 426, Taf.
1923. *Pachyseris cristata* Gerth, Samml. Geol. Reichsmus. Leiden Ser. I, Bd. X, p. 113
1925. *Pachyseris* cf. *torresiana* Gerth, Leidsche Geol. Med. I, p. 42

A common species in the Prupuk reef. Many specimens in an excellent state of preservation. Costae on the lower surface radially arranged and perpendicular to the nearly concentric collines on the upper surface. Collines mostly continuous over great distances, locally, however, thinning and wedging out after a short distance. Such a fragment from Prupuk was described by Gerth as *P.* cf. *torresiana*. This shows the danger inherent to identification of small and badly preserved fragments. The same is true for *P. curvata*, *P. cristata* and *P. laticollis* from Litjitjangkang Java, as described by Martin. A comparison of the type material with a large and well preserved suite from Prupuk shows that they all belong to a single species. Martin's type of *P. curvata* is a fragment with regular concentric collines but the columella is preserved only fragmentary. *P. vandijki* Gerth also is only a badly damaged *P. curvata*. Doubtless *P. cristata* Gerth from Borneo also belongs to the same species. Finally I restudied Dollfuss' speci-

men identified as of *P. laticollis* from the Pleistocene of Celebes. It is a poorly preserved fragment of a *Pachyseris* with equal septa, 18 in 5 mm. The columella is not preserved and specific identification is impossible, but it does not belong to *P. curvata*. Smith's specimen from the Philippinus was not available.

The following description is based on all of the material mentioned above but especially on the corals from Prupuk.

Collines mostly concentrically arranged. Distance between collines as measured from crest to crest 3 to 5, mostly 4 to 5 mm. Collines generally sharply roof-shaped, only locally rounded. Growth-shape of the coral a flat plate, sometimes undulating in an irregular fashion. Thickness varies from 3 to 12 mm., mostly 5 to 8 mm. Crowded layers of trabeculae are visible in cross section. Lower side covered by an epitheca through which a number of costae may be seen, 10 in 5 mm. If, however, the epitheca is worn off many more thin costae appear to be present viz. 20 in 5 mm. Septa mostly of equal length and thickness; only locally unequal and alternate. Most of the septa end in a T-shaped thickening. Septal sides with sharp and distinct granules, septa generally 14 to 16 in 5 mm. Columella a repeatedly interrupted lamella.

According to the list of synonyms given above, *P. curvata* Martin is now known from the upper Miocene of Liotjitjangkang (Tjilanang beds of Java); Neogene of Bor- (Sg. Goleh), Uppermost Miocene of Tjisande, Java; Upper Pliocene (Upper Kalibeng beds) of Java and from the boring of Ngembak.

Genus CYATHOSERIS Milne-Edwards and Haime

CYATHOSERIS LOPHIOPHORA Felix

Plate 82, figure 2

1921. Felix, Pal. v. Timor IX, p. 42, pl. 143, fig. 1, 1a
1923. Gerth, Samml. Geol. Reichsmuseum Leiden Bd. X, p. 105

This very characteristic species occurs commonly on the Tjisande and Prupuk reefs. In our collection from Prupuk it is represented by large fragments of apparently enormous colonies. The species was described by Felix and Gerth from the Upper Miocene of Borneo and I have found it in the Upper Pliocene (Upper Kalibeng beds) and Lower Pleistocene (Peutjangan beds) of Java.

CYATHOSERIS cf. CRASSILAMELLATA Gerth

Plate 81, figure 7

1923. Gerth, Samml. Geol. Reichsmuseum X, p. 104, Taf. 8, fig. 7

I compared the specimens from Tjisande and Prupuk with Gerth's holotype in the Leiden Museum. A certain identification is not possible as the Tjisande specimen is badly worn and the Prupuk specimen, though better preserved, is only a small fragment. However, the irregular arrangement of the ridges, the development of septacostae, the size and arrangement of the calices and the radial ridges on the lower side, agree with Gerth's type. It seems to me, therefore, that we are indeed dealing with the same species. The species was described by Gerth from the Upper Miocene of Borneo.

Genus LEPTOSERIS Milne-Edwards and Haime

LEPTOSERIS HAWAIIENSIS Vaughan

Plate 82, figure 5

1907. *Leptoseris hawaiiensis* Vaughan. U. S. Nat. Mus. Bull. 59, p. 137, pl. 39, 40
1921. *Leptoseris hawaiiensis* Vaughan. Van der Horst, Siboga Exp. Monogr. XVIb, p. 31
1922. *Leptoseris hawaiiensis* Vaughan. Van der Horst, Linnean Soc. London Trans. Jour., vol. 18, p. 421, pl. 32, fig. 1

The corallum is attached to folium of *Cyathoseris lophiophora* Felix, its central part crateriform, the more distal parts nearly horizontally extended. The fragment measures 62 mm. from the central calice to the most distal part of the lamen. Around the central calyx the others are irregularly scattered, occasionally grouped together, but not forming continuous valleys. Calices subcircular or elliptical from 2 to 4 exceptionally 6 mm. in diameter. The proximal sides of the calices are slightly swollen especially the distal ones. The number of septa varies from 12 to 24. Calicular fossa narrow, not deep. Columella seems to be composed of one or a few papillae in undamaged calices but it is of irregular shape in worn ones. Septocostae thin alternating

in size and finely granulate. Septa and septocostae imperforate. The lower surface of the corallum cannot be studied. The folium seems, however, rather thick and shows dissepiments in its basal portion.

I have no hesitation in referring this fossil to the recent species *L. hawaiiensis* Vaughan, as it agrees in every respect, especially with the specimens described by Van der Horst (1922) from Amirante.

Genus PAVONA Lamarck

PAVONA CLAVUS (Dana)

1880. *Pavona folium* Martin, Tert. schichten Java, p. 144
1912. *Siderastraea* cf. *sphaeroidalis* Ortman Felix, Plioc. korallen N. Guinea, p. 435
1913. *Siderastraea columnaris* Felix, Palaeontogr. L.X., p. 334, Taf. 26, fig. 3
1915. *Siderastraea columnaris* Felix, Pal. von Timor II, p. 35
1922. *Pavona clavus* Dana. Van der Horst, Linn. Soc. London, Trans., vol. XVII, 1, p. 420, pl. 31, fig. 7 (older synonyms)
1923. *Pavonia maldivensis* (Gardner). Gerth, Borneo, p. 109
1924. *Siderastraea clava* Dana. Umbgrove, Ceram, p. 12, pl. II, fig. 8
1925. *Pavona clavus* Dana. Gerth, Nias, p. 35
1926. *Pavona clavus* Dana. Umbgrove, Sumatra, p. 43
1936. *Pavona garanbiensis* Yabe and Ehara, Imp. Acad. Tokyo Proc., vol. 12, p. 25, fig. 3–5
1936. *Pavona maldivensis* (Gard.) Yabe, Sugiyama and Eguchi, Sci. Rep. Tohoku Imp. University, sec. ser. special vol. I, p. 57, pl. 58, fig. 4, 5
1939. *Pavona clavus* Dana, Umbgrove, p. 47

This species is known in different growth types; massive, forming clavate columns, sometimes giving origin to rather slender irregular branches, and in the form of plates which may be one to a few centimeters thick. The variation in shape, arrangement and septal number of the calices is well illustrated in many publications on the living corals from the Indo-Pacific region. I agree with the synonymy as given by Van der Horst; I have some doubt, however, about the correctness of his placing *P. duerdeni* Vaughan among the synonyms. I have studied Martin's specimen of *P. folium;* it belongs without doubt to the group of *P. clavus* (= *maldivensis*).

The figures of *Siderastraea columnaris* Felix are not good, but judging from his description it certainly belongs to *P. clavus.* Felix pointed out that it was closely allied to this species, and that its calices are identical to those of *Siderastraea sphaeroidalis* Ortmann, a species also described by Felix from New Guinea and which now is placed among the synonyms of *P. clavus* Dana. Judging from the description *Siderastraea blanckenhorni* Felix from the Pliocene of Java, probably should also have been placed among the synonyms of *P. clavus;* the figures given by Felix are schematic and for a conclusive opinion the specimen should be restudied. I have no hesitation in referring the recent "species" *P. garanbiensis,* described by Yabe and Ehara from Taiwan, to *P. clavus,* as the characteristics on which that new species was founded fall within the limits of variability of *P. clavus.*

Genus PAVONARAEA Umbgrove, n. genus

I have to constitute a new genus for two species. One was formerly described as *Pachyseris* (*Comoceris*) *javana* Gerth. The other one, *Pavonaraea irregularis* n. sp., described below, is selected as the genotype.

The most characteristic features of the new genus are as follows: The coral has collines, resembling more or less those of *Pachyseris,* but the septa unite in distinct calicular centra most resembling those of *Pavona.* Calices often arranged in linear series between the collines, but in places scattered irregularly even on the top of a collines.

Gerth, when describing *Pachyseris javana* from the Miocene of Java (1922, p. 427), pointed out that it differed from other species of *Pachyseris* in having separated calicular centres in the valleys. According to his opinion *P. javana* might eventually be referred to *Comoseris.* On account of the structure of the calices, which in Gerth's type resemble those of *Pavona,* I believe that this species should be placed in the genus *Pavonaraea. P. javana* differs from *P. irregularis* by its much smaller calices, regularly arranged in distinct valleys, and by its growth-type.

No recent species of this genus is known to me.

PAVONARAEA IRREGULARIS
Umbgrove, n. sp.
Plate 82, figure 3

The holotype is a fragment 17 mm. thick showing a parallel structure of thin layers

and apparently belonging to a colony of massive growth type. The slightly undulating upper surface is covered with collines and rather deep calices. Collines nearly parallel, often continuous for 30 mm.; sometimes irregular and dividing to form a connection with a neighboring colline. Calices often in linear arrangement; 3 to 6 in one series, in the deepest part of the valleys between the collines. Average distance of calicular centres in the same series 3 mm. Collines 3 to 4 mm. high, measured from the centre of a calyx to the top of a colline. In places, however, the calices are scattered in an irregular manner; some calices even occurring like small craters on the top of a colline. Twelve to 24 septo-costae radiate from the calices, continuous over the collines. On the top of a colline 40 septo-costae occur in one centimeter. Synapticulae distinct, especially between the septo-costae. Columellae mostly indistinct, when visible consisting of one or more small papillae.

Genus COSCINARAEA Milne-Edwards and Haime

COSCINARAEA COLUMNA (Dana)

Plate 81, figure 2

1846. *Psammocora columna* Dana U. S. Explor. Exped. Zooph., p. 347, pl. 25, fig. 1
1898. *Psammocora savigniensis* Gardiner, Zool. Soc. London Proc., p. 538, pl. 45, fig. 4
1925. *Coscinaraea columna* (Dana). Hoffmeister, Carnegie Instit. publ. 343, pl. 4, fig. 3

The fossil specimens agree not only in form of growth but also in every detail of structure with this recent species. It is a columnar mass with rounded summit 185 mm. high. Its nearly circular diameter is larger in the upper part of the colony (140 mm.) diminishing to 50 mm. at the base where it is broken off. This shape is produced by layers about 3 mm. thick growing from the top downwards upon each other, but the higher layers do not overlap the lower ones. Calices 1 to 5 mm. in diameter, rounded polygonal 1 to 2 mm. deep, mostly occurring in series from 2 to 5 centers, arranged in slightly gyrose valleys. Collines rounded, trabecular, having a reticular appearance, up to 4.5 mm. wide measured from fossa to fossa. Septa usually slightly thicker than the space between them, varying in number; in well developed single calices 12 reach the center. Septa of later cycles fused with the primary septa before reaching the fossa. The full number in large calices is 36. Septal edges granular; septal faces covered with minute spines. The calicular fossae round, 0.5 cm. or less in diameter. Columella false, consisting of trabeculae from the septa, sometimes ending in a few papillae.

Perhaps *C. columna* (Dana 1846) and *C. monile* (Forskål 1775) belong to the same species but this can be determined only by a thorough study of a large suite of recent specimens. I have discussed the different recent species of *Coscinaraea* at length in my paper on recent corals from the Togian Islands.

MADREPORARIA PERFORATA

Family ACROPORIDAE Verrill

Genus ASTREOPORA de Blainville

ASTREOPORA MYRIOPHTHALMA (Lamarck)

1880. *Astreopora myriophthalma* (Lam.). Martin (Java), p. 147, pl. 25, fig. 12
1918. *Astreopora myriophthalma* (Lam.). Vaughan, p. 146, pl. 60, fig. 5, 5a
1939. *Astreopora myriophthalma* (Lam.). Umbgrove, p. 53
1940. *Astreopora myriophthalma* (Lam.). Umbgrove, p. 302

A single specimen is in part well preserved and can be identified. I have compared the fossil with a suite of recent specimens from the bay of Batavia and the Togian Islands. I have restudied the type described by Martin and the specimen identified by Felix as *Astreopora ehrenbergi* Bern. var. *sphaerostoma* Ehr. (in the Mining Institute at Delft). The latter is a specimen of *Polysolenia hochstetteri* Reuss.

Distribution.—Upper Miocene (Tji Lanang beds) of Java; Plio-Pleistocene of Timor; Recent Indo-Pacific.

Genus TURBINARIA

TURBINARIA CRATER (Pallas)

1907. *Turbinaria crater* (Pallas), Bedot, p. 240, pl. 37, fig. 192–196
?1923. *Turbinaria* sp. Gerth, Borneo, p. 123, pl. 9, fig. 9
1939. *Turbinaria crater* (Pallas). Umbgrove, p. 54

The only fragment is an undulating folium 5 to 7 mm. thick. In part of the upper surface all calices are of the projecting type, elsewhere only immersed calices occur.

Calices 1 to 2, usually 1.5 mm. in diameter. Septa, columella and coenenchyma agree with the description and figures of Bedot's specimen. I compared the fossil with a suite from the bay of Batavia collected by Dr. Verwey. Perhaps the fossil *Turbinaria* sp. described and figured by Gerth from the Miocene of Borneo belongs to this species.

TURBINARIA sp.

Another species of *Turbinaria* is represented by a single fragment from Gunung Linggapadang. It has very small projecting calices 0.25 mm. in diameter. The specimen, however, is not well preserved, cannot be studied in detail and identification is not possible.

Genus MONTIPORA Quoy and Gaimard
MONTIPORA DUBIOSA Gerth

1921. *Montipora dubiosa* Gerth, Java, p. 432, pl. 56, fig. 16–17
1923. *Montipora dubiosa* Gerth, Borneo, p. 116

This species occurs commonly at Gunung Linggapadang and Gerth's description is entirely applicable. The secondary septa seem to be restricted to the upper part of the calices; consequently worn fragments show only the six primary septa.

Distribution—Upper Miocene (Tji Lanang beds) of Java. Miocene of Borneo.

Genus ACROPORA Oken

Many branches, sometimes occurring in dense accumulations. A specialist might be able to identify several species.

Genus GONIOPORA Quoy and Gaimard
GONIOPORA TENUIDENS (Quelch)
Plate 82, figure 4

1939. *Goniopora tenuidens* (Quelch). Umbgrove, p. 56 (with synonymy)
1940. *Goniopora tenuidens* (Quelch). Umbgrove, p. 304
1943. *Goniopora tenuidens* (Quelch). Umbgrove, Celebes, p. 15

I have compared the fossil specimens from Gunung Linggapadang with an excellent suite of recent corals from the Togian Islands. The fossils are rather badly worn but in one specimen, some calices have escaped destruction. They agree so well with the recent colonies that a description seems unnecessary. There is no difference in growth type (pulvinate), dimensions and structure of corallum and calices etc. between the fossil and recent corals.

Distribution.—Pleistocene, Celebes; Recent, Indo-Pacific.

Genus DICTYARAEA Reuss
DICTYARAEA ANOMALA Reuss

1867. *Dictyaraea anomala* Reuss, p. 177, pl. 3, fig. 3, 4, 5
1931. *Dictyaraea anomala* Reuss. Gerth, p. 144, synonymy

This well-known species occurs abundantly in Gunung Linggapadang.

Distribution.—Upper Miocene: Java (Njalindung, Tji Lanang beds), Borneo; Pliocene: Java (Duku Pengkol), New Guinea; Plio-Pleistocene: Timor.

Genus PORITES Link

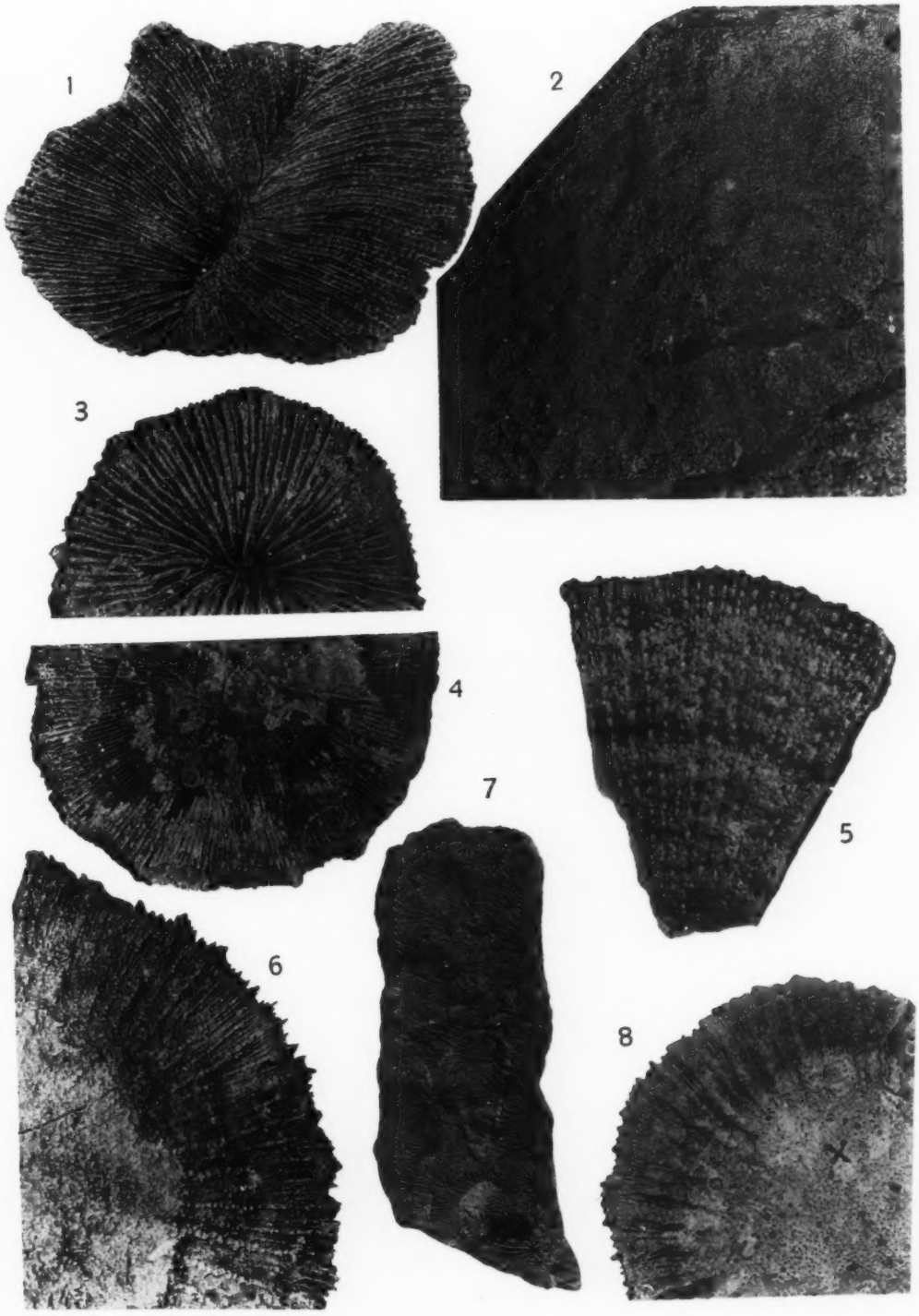
Specimens of *Porites* occur in two growth types, noduliform and branched. I have not identified any of them, as almost all are imperfectly fossilized. It is doubtful if even a specialist could identify them.

Genus ALVEOPORA Quoy and Gaimard
ALVEOPORA POLYACANTHA Reuss
Plate 80, figure 3;
Plate 82. figure 1

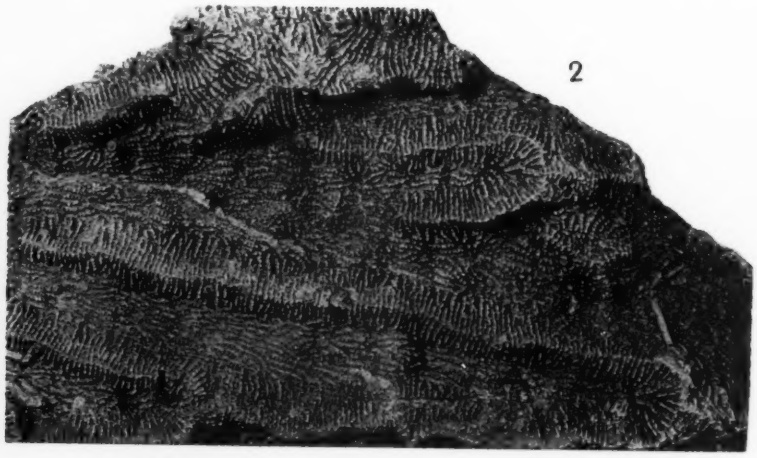
1867. *Alveopora polyacantha* Reuss, p. 178, pl. 3, fig. 5
1867. *Alveopora brevispina* Reuss, p. 178, pl. 3, fig. 6
1913. *Alveopora* cf. *polyacantha* Reuss. Felix, Java, p. 326
?1921. *Alveopora micropora* Felix, Borneo, p. 55, pl. 142, fig. 13, 13a
1921. *Alveopora polyacantha* Reuss. Gerth, Java, p. 437

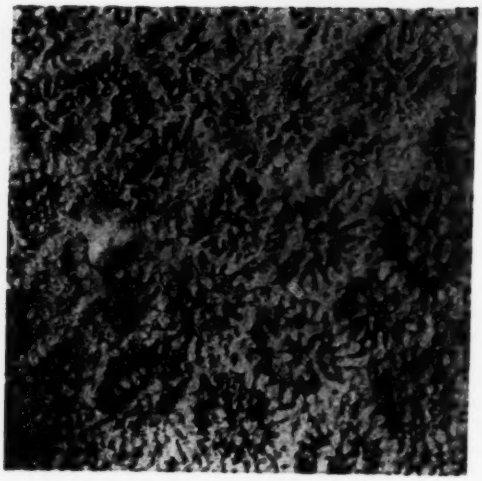
EXPLANATION OF PLATE 81
(All figures natural size unless otherwise indicated.)

FIG. *1—Fungia (Herpolitha?) praecursor* ten Dam, n. sp., Holotype. (p. 535)
2—Coscinaraea columna (Dana). (p. 539)
3, 4—Fungia distorta Michelin. *3*, A specimen, ×⅔; *4*, another specimen, ×13/14. (p. 533)
5, 6—Fungia concinna Verrill. *5*, A specimen, ×⅔; *6*, another specimen actual size. (p. 534)
7—Cyathoseris cf. crassilamellata Gerth. (p. 537)
8—Fungia inaequicostata Gerth, ×⅔. (p. 534)



Umbgrove, Lower Pliocene Corals





Umbgrove, Lower Pliocene Corals

1923. *Alveopora polyacantha* Reuss. Gerth, Borneo, p. 122

This species occurs commonly at Gunung Linggapadang. More than 30 branches were collected varying in diameter from 5 to 40 mm. Most of them have very little or no coenenchyma between the calicular walls; in places, however the calices are 1 to 2 mm. distant, a well developed coenenchyma being present. These parts strongly resemble *A. micropora* Felix, which I believe is a synonym of the present species especially as the diameter of the calices varies from 1 to 2.5 mm, although they are usually 1.5 to 2 mm. in diameter.

Distribution.—Miocene, Java, Borneo; Pliocene, Java.

Alveopora sp.

There are two fragments of a massive semiglobular coral from Gunung Linggapadang, which belongs to a species different from *A. polyacantha*. The specimens are, however, not well enough preserved for specific identification.

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Explanation of Plate 82

(All figures natural size unless otherwise indicated)

Fig. *1—Alveopora polyacantha* Reuss. (p. 540)
2—Cyathoseris lophiophora Felix, ×¾. (p. 537)
3—Pavonaraea irregularis ten Dam, n. sp., Holotype, ×¾. (p. 538)
4—Goniopora tenuidens (Quelch). (p. 540)
5—Leptoseris hawaiiensis Vaughan, ×3/2. (p. 537)

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JOURNAL OF PALEONTOLOGY, VOL. 20, NO. 6, PP. 543–555, PLS. 83, 84, 1 TEXT FIG., NOVEMBER 1946

MIDDLE MESOZOIC NONMARINE OSTRACODA FROM BRAZIL AND NEW MEXICO

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ABSTRACT—Eight new ostracode species and two new varieties from the Bahia beds of Brazil, and one new species from the Todilto limestone member of the Morrison formation of New Mexico are described and illustrated. Four additional species from the Bahia beds are discussed. A new subgenus of *Cypridea* Bosquet, here named *Paracypridea*, is introduced, and Roth's genus *Pseudocypridina* is redefined as a subgenus of *Cypridea*.

The evidence suggests that the major part of the subsurface Bahia beds in the Bahia embayment is Upper Jurassic (Purbeck), and there is reason to believe that the uppermost Bahia may be early Lower Cretaceous (Wealden).

The Todilto limestone member of the Morrison contains a species related to *Metacypris whitei* Jones of the Upper Jurassic Morrison formation, but the more typical Morrison Ostracoda are not known in the Todilto.

INTRODUCTION

THE BAHIA beds comprise a sequence of clay shales, limestones, sandstones and conglomerates that are overlain by Tertiary sediments and occur in a north-south trending embayment in the vicinity of the Bay of Todos Os Santos, Bahia Province, Brazil (Hedburg, 1945). Structurally, the basin is a graben that is bounded on the east and west by basement rocks. The only oil production in Brazil comes from the Bahia beds, of which over 6500 feet have so far been penetrated by drilling. Their fauna includes only fresh- or brackish-water types of vertebrates and invertebrates. Ostracoda occur at many horizons and form numerous layers of limestone coquina.

A recent book on Brazilian geology (de Oliveira and Leonardos, 1943) assigns the Bahia beds to the Cretaceous, but the ostracodes, at least, suggest a late Upper Jurassic age, although the uppermost beds may be of early Lower Cretaceous age.

Several lots of samples from surface collections and well-cores have been sent to the U. S. Geological Survey by the Conselho Nacional do Petróleo of Brazil. In one lot of samples including a surface collection and cores from several wells ranging in depth from 600 to 4650 feet Reeside (unpublished report) recognized *Corbicula* sp., *Estheria* cf. *E. ovata* Lea or *E. forbesii* Jones, cyprid ostracodes, and fragmentary fish bones.

In a preliminary examination of the ostracodes in core samples, presumably from a single well, and ranging in depth from 1915 to 2225 feet, I. Gregory Sohn provided the following identifications in an unpublished report:

Cypridea? n. sp. aff. *C. punctata* (Forbes)—1915–2225 feet.
Cypridea? n. sp.—1925–2225 feet.
Cypridea sp. aff. *C. posticalis* (Jones)—2225 feet.
Cypris? sp. aff. *C. purbeckensis* Forbes—1915–?2225 feet.
Cypris? n. sp.—1915–2225 feet.
Darwinula sp. aff. *D. leguminella* (Forbes)—1915–2225 feet.
Metacypris? sp. aff. *M. pahasapensis* (Roth)—1925–2225 feet.
Metacypris? n. sp.—2036–2225 feet.

The occurrence in Sohn's material of forms related to the English Purbeck species *Cypridea punctata, C. posticalis, Cypris purbeckensis* and *Darwinula leguminella* and the Morrison species *Metacypris pahasapensis* led him to feel that the collection most probably was of Upper Jurassic age.

In 1860, Jones described four species and recorded a fifth in a surface collection from the Bahia beds near Montserrate Hill, Bahia Province, as follows:

Cypris? allportina Jones
Cypris? conculcata Jones
Cypris? montserratensis Jones
Cypris? sp.
Candona candida (Müller)

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In a discussion of collections from the Morrison formation of Colorado, Jones later (1886) stated that *Cypris? allportina* probably is a *Darwinula*, to which I would agree, and that *C.? conculcata* resembles *Metacypris whitei* Jones, a conclusion not apparent on comparison of Jones' illustrations of the Bahia and Morrison species.

I examined a surface collection from the Bahia beds labeled Aratú, Quadrangle 30, Section H, and cores from well No. B-40, Mata São João, ranging in depth from 4893 feet to 6525 feet which were sent to the U. S. Geological Survey by the Conselho Nacional do Petróleo of Brazil. In the samples, the only one of Jones' species that was identified with fair certainty is *Candona candida* (Müller). The species herein identified with *Darwinula dakotensis* Harper and Sutton may possibly be the same as *Cypris? allportina* Jones, although as figured, the latter is more elongate.

The surface collection, a washed sample, having preserved only fragments of buff silty clay matrix, contains small gastropods and the following ostracodes:

Cypris bahiensis Swain, n. sp.
Candona? striatula Swain, n. sp.
Candona? cf. *C. candida* (Müller)
Cypridea quadrilateralis Swain, n. sp.
Cypridea (*Paracypridea*) *obovata* Swain, n. sp.
?Metacypris postangularis Swain, n. sp.
Metacypris paucisulcata Swain, n. sp.

The core-samples consist of light gray and greenish, partly silty clay, bearing small phosphatic pellets, and white to gray coquinoid limestones. Ostracodes are abundant in all of the material, and the coquinas are made up almost entirely of compacted shells of *Cypris* cf. *C. bahiensis*, n. sp., together with forms resembling *Candona ansata* Jones.

The ranges of the various species that were recognized in the material at hand are as follows:

Cypris bahiensis, n. sp.—Surface–6525 feet.
Candona? striatula, n. sp.—Surface.
Candona? aff. *C. ansata* Jones—5693–6525 feet.
Candona? cf. *C. candida* (Müller)—Surface–6239 feet.
Cypridea cf. *C. punctata* (Forbes)5693–?6239 feet.
Cypridea quadrilateralis, n. sp.—Surface–6092 feet.
Cypridea (*Pseudocypridina*) *piedmonti* (Roth)—4893 feet.
Cypridea (*Paracypridea*) *obovata*, n. sp.—Surface.
Metacypris postangularis, n. sp.—?Surface–5702 feet.
Metacypris postangularis var. *inornata*, n. var.—4893 feet.
Metacypris ventrosa, n. sp.—5693–5702 feet
Metacypris paucisulcata, n. sp.—Surface.
Metacypris? trinodosa, n. sp.—5693–5702 feet.
Darwinula dakotensis Harper and Sutton 4893–5702 feet.
Darwinula dakotensis var. *microstriatula*, n. var.—4893 feet.

Candona? cf. *C. candida* is very close to *C. ansata* Jones, from the Lower Purbeck of England, additional work may show them to be identical. *Cypridea punctata* s.s. is confined to the middle and upper Purbeck beds of England, although its tuberculate varieties range up into the Wealden. *Darwinula dakotensis* a species of the Morrison formation, here recorded also from the Bahia beds, is close to *D. leguminella* of the middle and upper Purbeck and Wealden of England and Germany, but the latter is more elongate, and may, in fact, be the same as Jones' Bahia species *Cypris? allportina*. *Metacypris postangularis*, n. sp. is related to the Morrison form *M. pahasapensis* (Roth) on the one hand, and to *M. forbesii* Jones of the middle Purbeck, on the other. Its sulcation is weaker than that of *M. pahasapensis* but stronger than that of *M. forbesii*. *Cypridea* (*Pseudocypridina*) *piedmonti* (Roth), a typical Morrison species, is present in the middle part of the Bahia sequence.

The greater part of the subsurface Bahia beds so far penetrated by drilling appears to be Purbeck in age, as judged by its ostracode fauna. The surface collection here studied contains a number of species not clearly related to either the Purbeck or the Morrison forms, nor can affinities be traced to the Wealden or the early Cretaceous nonmarine beds of the Rocky Mountain region (Peck, 1941). Among the species present at the surface, only *Metacypris postangularis* and *Candona candida* indicate relationship to the Purbeck. Because there are middle and upper Purbeck forms in the subsurface Bahia sequence, and because no well-defined lithologic differences or recognizable unconformities have been observed between the surface and the unexposed parts, the uppermost sediments might be tentatively regarded as possibly of early Lower Cretaceous age.

Also described herein is a new species of *Metacypris* from the Todilto limestone, the

basal member of the Morrison formation of northwestern New Mexico. The Todilto limestone in its type area, McKinley County, New Mexico, rests unconformably upon the Wingate sandstone (Baker, Dane, and Reeside, 1936, p. 9). In southeastern Utah and parts of southwestern Colorado the Todilto horizon is separated from the Wingate sandstone by several intervening formations. According to Reeside (personal communication) ostracodes like those described here are the only known fossils from the Todilto limestone of northwestern New Mexico. The limestone slabs provided by Dr. Reeside contain numerous ostracodes, all apparently belonging to a single species, here named *Metacypris toditensis*, n. sp. The form is closely related to the unisulcate section of *M. whitei* Jones, of the Morrison formation of Colorado. Additional studies should be made of the Morrison material, however, as Jones includes bisulcate forms in this species. *Metacypris toditensis*, on the other hand, is not at all closely related to the other Morrison examples of *Metacypris* as described by Roth (1933) and Harper and Sutton (1935), or the *Metacypris*-like *Theriosynoecum* of Branson (1935, 1936).

Appreciation for his assistance is expressed to Dr. John B. Reeside, Jr. The writer's work has been supported by the U. S. Geological Survey, and the type specimens are deposited in the U. S. National Museum.

DESCRIPTION OF SPECIES

Order OSTRACODA Latreille

Family CYPRIDAE Baird

Ostracoda having mostly thin, corneous shells; in some the shell may be calcareous, as in Recent examples of the subfamily Macrocyprinae and certain fossil examples of the other subfamilies. Surface of valves smooth, never roughly sculptured. Hinge simple, without interlocking denticulation.

Antennae in some groups adapted for swimming, in other groups for creeping. (Adapted from G. O. Sars, 1928).

Subfamily CYPRINAE Sars

Shell of varying shape and generally thin, never calcareous. Antennae mostly for swimming (Sars, 1928).

Remarks.—The subfamily includes a large number of Recent genera, to some of which fossils have also been referred, among them *Argilloecia*, *Paracypris*, *Candona*, and *Cypris*. The fossil representatives have calcareous shells that presumably represent original material. In the collections here described, calcified examples of *Candona* and *Cypris* occur in the same rock chips with uncalcified, corneous shells of *Estheria*. Sars' restriction of the Cyprinae has been emended in practice to include calcified fossil forms. Of the genera mentioned above, *Argilloecia* and *Paracypris* occur in definitely marine sediments, while *Candona* and *Cypris*, although apparently restricted to fresh- and brackish-water environments, are present in calcareous sediments, wherein they seem always to be calcified. It is not unreasonable to suppose that, as an aid in strengthening their shells, these ostracodes use lime carbonate when it is available to them.

Genus CYPRIS Müller, 1785

Animal swimming and creeping; inhabiting fresh water; eye single (coalesced); both pairs of antennae plumed.

Shell suboblong or subreniform; generally smooth and more or less setigerous, occasionally punctate; left valve larger than right, overlapping it along the free margins; hinge margin straight to scarcely incurved, and more or less distinctly defined by cardinal angles; ventral margin more or less incurved. Hinge simple, or with narrow furrows or flanges and slight ridges. Inner lamellae present, not coalescing with inner surface of valve, and projecting obliquely into shell concavity; broadest anteriorly. (Adapted from Jones, 1856).

CYPRIS BAHIENSIS Swain, n. sp.

Plate 83, figures 1–3

Shell suboblong in side view; highest about one-fourth distance from anterior end; dorsal margin straight, with well-defined, but very obtuse, cardinal angles; ventral margin nearly straight to scarcely concave; anterior end truncate above a rather sharply bent middle portion; posterior end more uniformly rounded, slightly truncate above. Left valve larger than right, projecting beyond it around entire periphery. Surface smooth.

Hingement and other internal features not observed.

Dimensions.—Length of holotype, a complete example, 1.50 mm., height 0.87 mm., thickness 0.65 mm.

Holotype.—U.S. Nat. Mus. 103837; paratypes, 103838, 103839.

Relationships.—In its outer features this species conforms to characters described for the genus *Cypris*. It is relatively higher, has a straighter hinge, and more pronounced cardinal angles than *C. purbeckensis* Forbes from the Lower Purbeck of England. *Cypris? montserratensis* Jones from the Bahia beds, Montserrate Hill, Bahia Province, Brazil (Jones, 1860, p. 266, pl. XVI, fig. 15) is more convex dorsally than the species under discussion.

Occurrence.—Very common in a surface collection from the Bahia beds labeled Aratú, Quadrangle 30, Section H, and in well collections from 5693 to 6525 feet, well No. B-40, Mata São João, Bahia Province, Brazil. The holotype is from the surface collection. The species was not recognized in an otherwise ostracodal shale sample from a core at 4893 feet in well B-40.

Genus CANDONA Baird, 1845

According to Jones (1885, p. 346), "Valves like those of *Cypris*. Difficult to be distinguished from that genus except by comparison with known recent forms; the structure of the soft parts supplying the initial differences." Without elaborating further Jones stated, in addition, that the English Purbeck ostracodes assigned by him to *Candona* reminded him of *Candona* rather than *Cypris*.

Remarks.—Species of *Candona* figured by Jones differ from the more typical examples of *Cypris* in having a rather strongly concave ventrum and a ventrally produced posterior end, but with the more or less straight hinge and rounded ends of *Cypris*. Whether these are true criteria for distinguishing the genera is uncertain and the following two species are assigned to *Candona* with reservations.

CANDONA? STRIATULA Swain, n. sp.
Plate 83, figures 4–6

Shell oblong-reniform in lateral view; dorsal margin gently convex, with nearly straight mid section; ends broadly rounded, the posterior end slightly the higher; ventral margin more or less concave in lateral view, the greatest indenture somewhat posterior to midlength. Right valve larger than left, overlapping and projecting beyond it; dorsally the projection is inconspicuous.

Surface ornamented with fine, closely-spaced, discontinuous, branching, longitudinal ridges and grooves in middle portions of valves; marginal areas apparently smooth. A low, blunt, rounded node lies a little ventrad of the anterocardinal, marginal bend. Greatest convexity about median.

Hingement and other internal features not observed.

Dimensions.—Length of holotype, a complete example, 1.05 mm., height 0.62 mm., thickness 0.43 mm.

Holotype.—U. S. Nat. Mus. 103840; paratypes, 103841.

Relationships.—The finely striate surface, the antero cardinal nodes, and especially the overlapping of the left valve by the right, as the species is oriented by the writer, serve to distinguish this species. Its concave ventrum, with otherwise *Cypris*-like shape allies it to the candonids of authors. The reversal in overlap may furnish basis for its recognition as a distinct genus, but inasmuch as such reversal has been recorded within some ostracode genera, and even within certain species, its separation as distinct from *Candona* is not now feasible.

Occurrence.—Known only from a surface collection marked Aratú, Quadrangle 30, Section H, Bahia Province, Brazil, furnished by the Conselho Nacional do Petróleo of Brazil.

CANDONA? cf. C. CANDIDA (Müller)
Plate 83, figures 16, 17; text figure 1b

Cypris candida Müller, 1785, Entomostraca, p. 62, pl. 6, figs. 7–9

Candona candida Jones, 1856, Monog. Tert. Entomos., p. 19, pl. 1, fig. 8.

Candona candida Jones, 1860, Geol. Soc. London, Quart. Jour., vol. 16, p. 267, pl. XVI, fig. 14.

Shell reniform-acuminate in lateral aspect; dorsal margin moderately convex; anterior end rounded and extended below; posterior end more sharply rounded, almost pointed, and strongly extended below; ventral margin concave, the strongest indenture lying about one-third from posterior

end. Left valve larger than right, overlapping it slightly. Surface smooth.

Muscle scar lies scarcely anterior to valve middle; it consists of six distinct spots arranged in a group, and a poorly defined area, perhaps including more than one spot, lying post-ventrad of the main group. In the main group of spots, the dorsal four form an arcuate subgroup, ventral to which are the two smaller spots. Hinge and other internal features unknown.

Dimensions.—Length of the figured specimen 1.0 mm., height 0.50 mm., thickness 0.46 mm.

Figured specimen.—U. S. Nat. Mus. 103842.

Relationships.—The specimens here studied agree with the specific characters defined by Jones (1860, p. 267). As compared to *C. ansata* Jones from the Purbeck of England, the species under discussion is more strongly produced postventrally, but otherwise it resembles the Purbeck example.

Occurrence.—Common in a surface collection labeled Aratú, Quadrangle 30, Section H, Bahia Province, Brazil. Also obtained from core No. 69, at 5693–5702 feet, and from core No. 104 at 6239 feet, well No. B-40, Mata São João. Jones' examples came from Montserrate Hill, Bahia Province.

Genus CYPRIDEA Bosquet

General outline subtriangular to obovate or ovate-oblong. Greatest height about one-third the distance from the anterior to the posterior extremity. Anterior extremity somewhat compressed and notched behind a beaklike projection at the anteroventral angle. Some specimens have only a slight indentation below and behind a thickening of the anteroventral angle, which may be traceable only by a curvature of the edge inside. Hinge line straight along the middle third of the dorsal edge and oblique to the main axis of the carapace. Left valve overlaps the right with a ridge and groove on the dorsal and ventral margins. Surface smooth, punctate, or pustulo-punctate.

Muscle scar as seen in one representative of the genus, *C.* (*Paracypridea*) *obovata*, n. sp., consists of an arcuate, submedially placed group of four spots, together with two slightly more posterior spots. Inner lamellae as seen in the above species narrow and almost coinciding with inner surface of valve along the ventrum, becoming somewhat broader anteriorly, and only slightly broader posteriorly.

Members of the genus apparently are confined to a fresh- or brackish-water habitat.

Remarks.—Roth (1933) established a genus *Pseudocypridina*, with *P. piedmonti* Roth as genotype, to include species which lack an anteroventral notch and hood, but

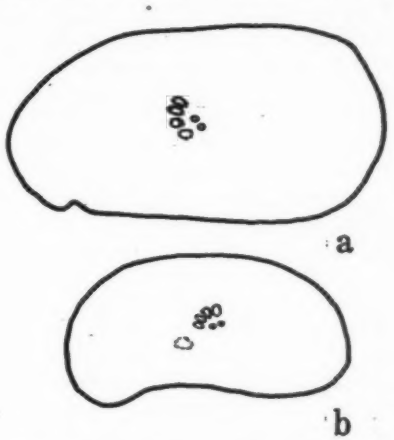

FIG. 1—a, *Cypridea* (*Paracypridea*) *obovata* Swain, n. sp., outline of exterior of holotype, a left valve, showing muscle scar pattern; surface collection, Bahia beds, Aratú, Bahia Province, Brazil. b, *Candona?* cf. *C. candida* (Müller), outline of left side of a shell, showing muscle scar pattern; Bahia beds, well No. B-40, Mata São João, Brazil, core No. 69, 5693–5702 feet.

otherwise resemble *Cypridea* and have an anteroventral beak. Harper and Sutton (1935) stated that in their opinion Roth had not demonstrated the lack of an anteroventral notch in his figured material, and consequently, the genotype of *Pseudocypridina* should be referred to *Cypridea*. This opinion is in agreement with Jones' understanding of *Cypridea*, as according to that author, "some specimens have only a slight indentation below and behind a thickening of the anteroventral angle, which may be traceable only by a curvature of the edge inside."

Among the species referable to *Cypridea* that are herein described, examples thought to be conspecific with *P. piedmonti* do not

have an observable furrow or notch that defines an anteroventral hood, as in more typical *Cypridea*, although the shell margin is slightly projected ventrally as a short beak. Roth's figures of *Pseudocypridina* likewise do not exhibit a notch or furrow on the valve surface at the anteroventral bend. It is therefore proposed that *Pseudocypridina* be redefined as a subgenus of *Cypridea*, to include those species that lack an antero-ventral notch and hood.

Another of the Bahia species referable to *Cypridea*, and here named *C. obovata*, n. sp., has the anteroventral notch, hood and beak of the genus, but contrary to typical *Cypridea*, the anterior end is lower than the posterior end, causing the dorsal and ventral margins to converge anteriorly instead of posteriorly. While it has been observed that the typical posterior convergence in *Cypridea* is subject to considerable variation (Peck, 1941), nevertheless, the antrad marginal convergence of *C. obovata* appears to be unique. In addition, this species has the right valve larger than the left, and overlapping it, a feature that cannot fully be evaluated on the basis of the material at hand, but for the present this will be considered as support for separation of the form from typical *Cypridea*. It is therefore proposed that a second subgenus, *Paracypridea*, be defined to include *Cypridea*-like species in which the anterior end is lower than the posterior end, and in which, at least in known examples, the right valve is larger than the left.

CYPRIDEA cf. C. PUNCTATA (Forbes)
Plate 83, figures 7–9

Cypris punctata Forbes, 1855, in Lyell's Manual of Elementary Geology, 5th Ed., p. 297, fig. 339b.

Cypridea punctata, Huxley and Etheridge, 1865, Catal. Coll. Foss. Mus. P. Geol., p. 254.

Cypridea punctata, Jones, 1885, Geol. Soc. London Quart. Jour., v. 41, p. 337, pl. VIII, figs. 1–8.

Shell subovate in lateral aspect; dorsal margin gently convex; anterior end broadly rounded, scarcely extended below; a short, blunt beak is present at antero-ventral bend; a narrow, subtriangular furrow or notch bounds the well-defined, antero-ventral hood on its posterior side; posterior end more narrowly rounded, slightly extended below; ventral margin nearly straight. Left valve slightly larger than right, overlapping and extending beyond it around entire periphery.

Surface bears small, widely spaced pits, except in a small median area, perhaps the

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EXPLANATION OF PLATE 83

FIGS. *1–3—Cypris bahiensis* Swain, n. sp., *1*, View of right side of holotype, a slightly imperfect shell. *2*, *3*, Dorsal and right valve views of two paratype specimens. *1*, *2*, Surface collection, Bahia beds, Aratú, Bahia Province, Brazil. *3*, Well, No. B-40, Mata São João, Brazil, core No. 69, 5693–5702 feet. ×40. (p. 545)

4–6—Candona? striatula Swain, n. sp. *4*, *5*, Left and right side views of two paratype specimens. *6*, Left valve view of holotype. Surface collection, Aratú, Bahia Province, Brazil. ×45. (p. 546)

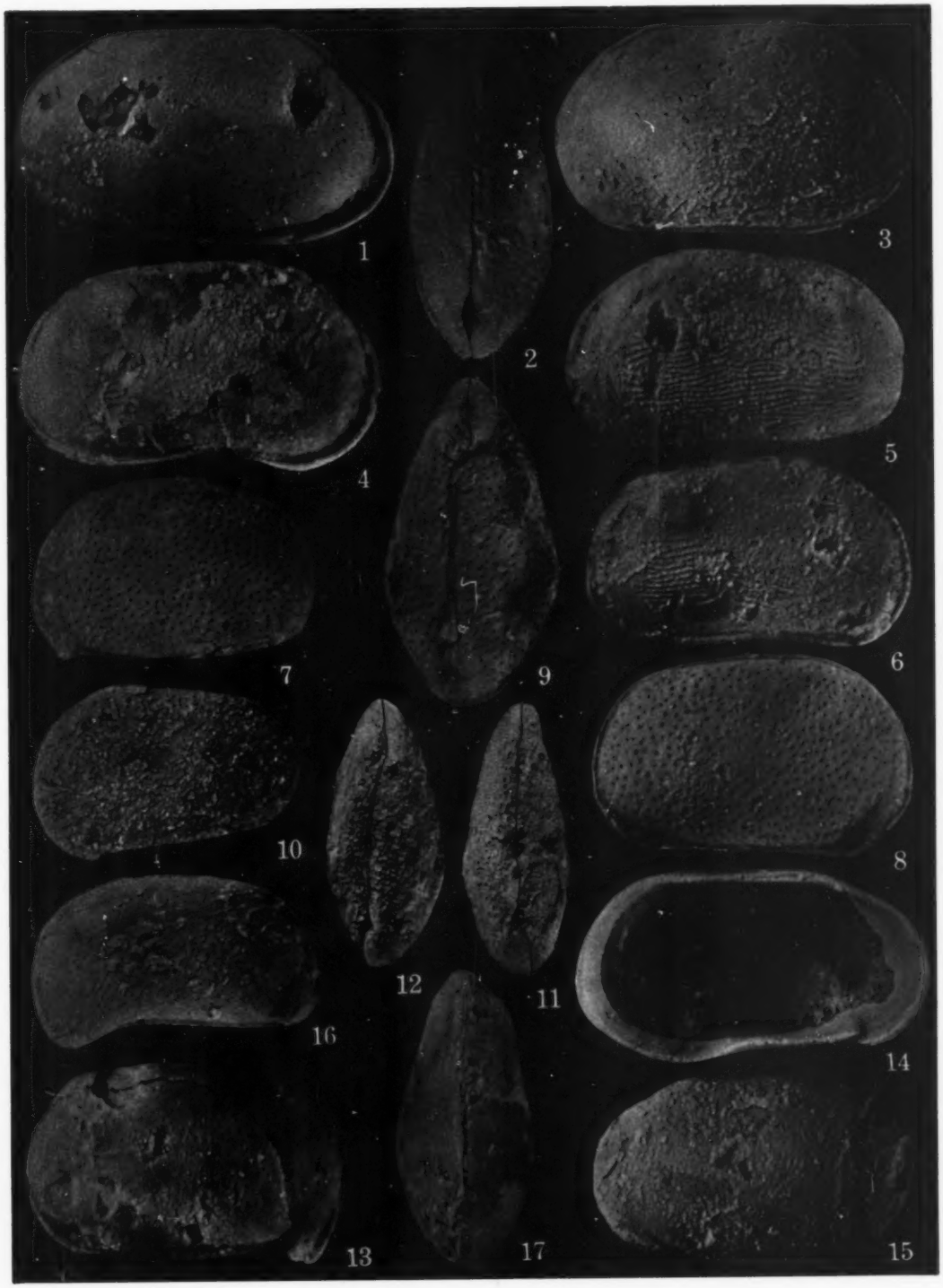
7–9—Cypridea cf. *C. punctata* (Forbes). Left, right and ventral views of specimens from the Bahia beds, well No. B-40, Mata São João, Brazil, core No. 69, 5693–5702 feet; *8* and *9* are the same specimen. ×45. (p. 548)

10–12—Cypridea (*Pseudocypridina*) *piedmonti* (Roth). Left, dorsal and ventral views of a specimen from the Bahia beds, well No. B-40, Mata São João, Brazil, core No. 62, 4893 feet. In *12* the margin of the left valve is slightly broken near the post-ventral bend, falsely suggesting a slight reentrant at this position. ×45. (p. 550)

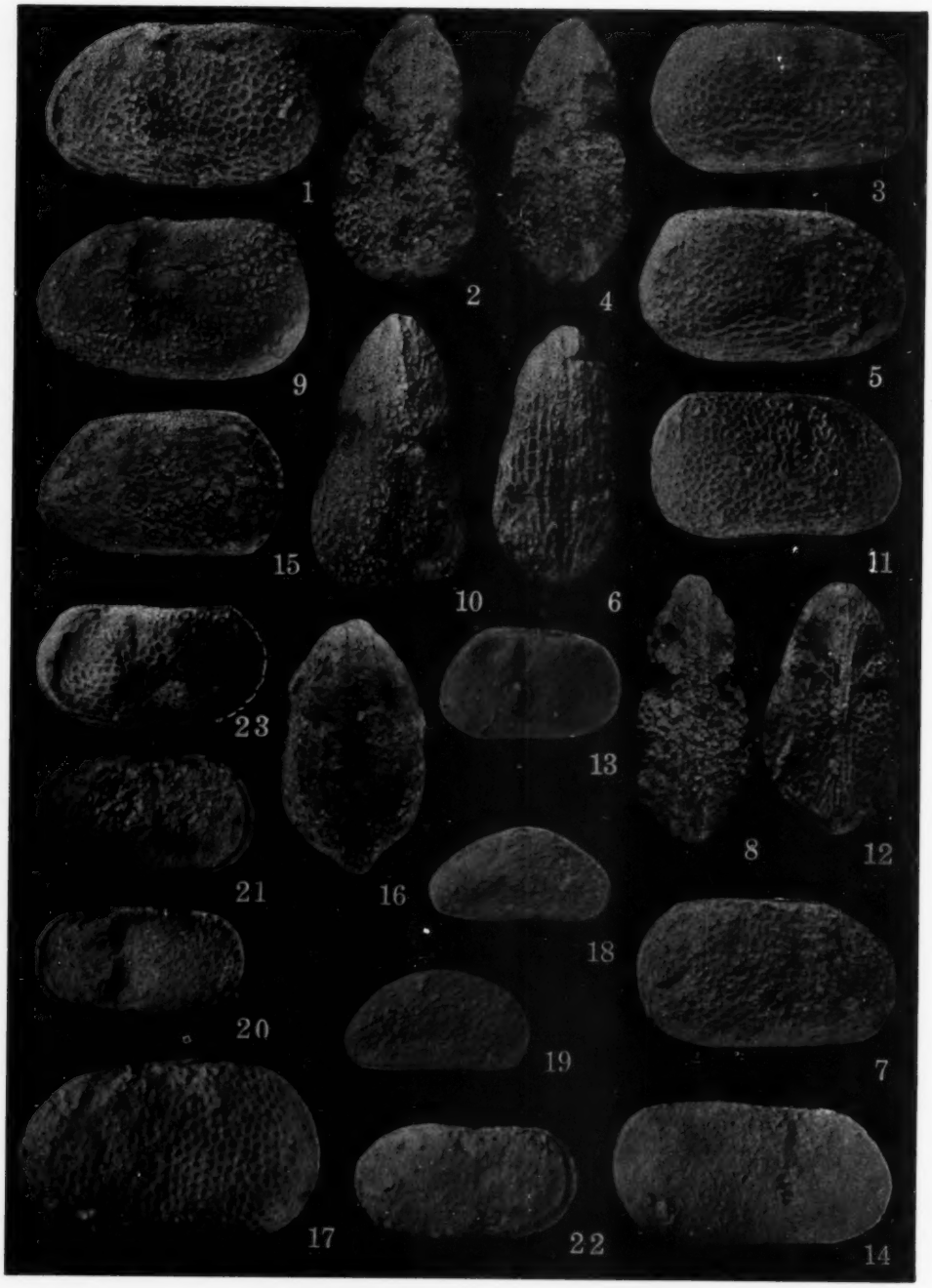
13—Cypridea quadrilateralis Swain, n. sp. Right valve view of holotype; the right valve is somewhat damaged. Surface collection, Bahia beds, Aratú, Bahia Province, Brazil. ×45. (p. 549)

14, 15—Cypridea (*Paracypridea*) *obovata* Swain, n. sp. *14*, View of interior of holotype, a left valve; the muscle scar is faintly exhibited. *15*, Left valve view of a paratype specimen. Surface collection, Bahia beds, Aratú, Bahia Province, Brazil. ×45. (p. 551)

16, 17—Candona cf. *C. candida* (Müller). Right side and dorsal view of a specimen from well No. B-40, Mata São João, Brazil, core No. 69, 5693–5702 feet. ×45. (p. 546)



Swain, Middle Mesozoic Ostracoda



Swain, Middle Mesozoic Ostracoda

site of the muscle scar, where ornamentation is lacking.

Hinge not clearly observed, but believed to be simple. Muscle scar and other internal features could not be observed either by transmitted or reflected light under oil, perhaps owing to crystallization of the shell material and inner matrix. All examples that were observed, whether they occur in shale or in chalky limestone, consist of light brown, crystalline calcite.

Dimensions.—Length of a well preserved specimen (plate 83, fig. 8) 1.00 mm., height 0.62 mm., thickness 0.51 mm.

Figured specimen. U. S. Nat. Mus. 103843.

Relationships.—The Bahia specimens agree with characters prescribed by Jones (1885, p. 338) for the examples from the Middle and Upper Purbeck beds of England and northern Germany.

Occurrence.—In the collections at hand, the species is common in a sample from core No. 69 at 5693–5702 feet, well No. B-40 of the Conselho Nacional do Petróleo, Mata São João, Brazil. It is questionably present in core No. 104 at 6239 feet.

CYPRIDEA QUADRILATERALIS
Swain, n. sp.
Plate 83, figure 13

Shell oblong-quadrate in lateral view; dorsal margin nearly straight, scarcely convex in middle portion, and about two-thirds shell length. Anterior end broadly rounded; posterior end slightly more narrowly rounded. Ventral margin nearly straight and subparallel to dorsal margin; prominent and well-defined anteroventral, deep notch and hood present, the latter produced ventrally into a blunt beak. As viewed ventrally, the valve beaks are not directly opposed, but fit together in an interlocking fashion; the right valve beak fits into a reentrant or marginal socket just behind the left valve beak; the beak of the left valve slightly overlaps that of the right. Left valve larger than right, the overlap greatest ventrally, becoming less terminally and scarcely discernible dorsally. Surface smooth. Greatest convexity about median.

Hingement not clearly observed, but apparently simple. Muscle scar and other internal features unknown.

EXPLANATION OF PLATE 84

FIGS. *1–8, 13, 14—Metacypris postangularis* Swain, n. sp. *1*, Left valve view of holotype, a female. *2, 3*, Dorsal and right valve views of a female paratype. *4, 5*, Dorsal and right valve views of a male paratype. *6*, Ventral view of a male paratype. *7, 8*, Right side and dorsal views of a male paratype. *13, 14*, Internal molds of two examples showing muscle scar pattern. *1–8*, Bahia beds, well No. B-40, Mata São João, Brazil, core No. 62, 4893 feet. *13*, Core No. 69, 5693–5702 feet. *14*, Surface collection, Aratú, Brazil. ×45. (p. 551)

9, 10—Metacypris postangularis inornata Swain, n. var. Left side and dorsal views of holotype. Bahia beds, well No. B-40, Mata São João, Brazil, core No. 62, 4893 feet. ×45. (p. 552)

11, 12, 15, 16—Metacypris ventrosa Swain, n. sp. *11, 12*, Right side and dorsal views of holotype; ventrally the holotype is somewhat damaged. *15, 16*, Left side and ventral views of a partly exfoliated paratype, showing muscle scar and broadened, impressed ventrum. Bahia beds, well No. B-40, Mata São João, Brazil, core No. 69, 5693–5702 feet. ×45. (p. 552)

17—Metacypris paucisulcata Swain, n. sp. Left valve view of holotype. Surface collection, Bahia beds, Aratú, Bahia Province, Brazil. ×45. (p. 553)

18—Darwinula cf. *D. dakotensis* Harper and Sutton. Left valve view of a specimen from the Bahia beds, well No. B-40, Mata São João, Brazil, core No. 62, 4893 feet. ×45. (p. 554)

19—Darwinula dakotensis microstriatula Swain, n. var. Left valve view of holotype. Bahia beds, well No. B-40, Mata São João, Brazil, core No. 62, 4893 feet. The longitudinally striate surface is not well illustrated. ×45. (p. 554)

20–22—Metacypris todiltensis Swain, n. sp. *20*, Left valve views of holotype. *21, 22*, Right valve views of two paratypes. Todilto limestone member of the Morrison formation. six miles north of Thoreau, New Mexico. ×45. (p. 553)

23—Metacypris? trinodosa Swain, n. sp. View of exterior of holotype, a left valve that is incomplete posteriorly. Bahia beds, well No. B-40, Mata São João, Brazil, core No. 69, 5693) 5702 feet. ×45. (p. 554)

Dimensions.—Length of holotype 1.05 mm., height 0.67 mm., thickness 0.50 mm.

Holotype.—U. S. Nat. Mus. 103844.

Relationships.—The quadrate outline, together with the smooth surface of this species distinguish it from other described members of the genus.

Occurrence.—Common in a surface collection labeled Aratú, Quadrangle 30, Section H, donated by the Conselho Nacional do Petróleo. A single specimen also obtained from core No. 90 at 6092 feet, well No. B-40, Mata São João, Brazil.

Subgenus PSEUDOCYPRIDINA Roth

Pseudocypridina Roth, 1933, Jour. Paleontology, vol. 7, no. 4, p. 404.

Ostracodes that otherwise resemble Cypridea, but lack an anteroventral notch and hood, although the characteristic beak is present at the anteroventral marginal bend.

CYPRIDEA (PSEUDOCYPDIDINA) PIEDMONTI (Roth)

Plate 83, figures 10–12

Pseudocypridina piedmonti Roth, 1933, Jour. Paleontology, vol. 7, no. 4, p. 404.
Cypridea piedmonti, Harper and Sutton, 1935, Jour. Paleontology, v. 9, no. 8, p. 625.

Shell subovate in lateral view; highest about one-third from anterior end; the dorsal margin is nearly straight posterior to greatest height for about one-half shell length. Anterior end broadly rounded; at the anteroventral bend on the left valve, as viewed laterally, there is a small beak-like projection, but there is no development of a hood and postjacent furrow at this position; the right valve lacks the beak entirely, so that in right valve view, the left valve beak projects strongly beyond the margin of the right at the anteroventral bend. Posterior end narrowly rounded. Ventral margin nearly straight for much of its length, scarcely concave just behind the beak. Left valve larger than right and extending beyond it around the entire margin. Surface smooth. Greatest convexity in posterior third of shell.

Hingement not clearly observed, but apparently simple, about one-half shell length, and without discernible terminal hinge teeth and sockets. Muscle scar not seen.

Dimensions.—Length of a figured specimen 0.92 mm., height 0.54 mm., thickness 0.40 mm.

Figured specimens.—U. S. Nat. Mus. 103845.

Relationships.—In their general outline, lack of antero-ventral hood and notch, and smooth surface, the Bahia examples appear to be conspecific with the Morrison species *C.* (*P.*) *piedmonti*. Among the latter examples, one figured by Harper and Sutton (1935, pl. 76, fig. 13) has the greatest height almost at midlength, and possibly does not belong to this species.

Occurrence.—Very abundant in a sample of greenish-gray shale, core No. 62 at 4893 feet, well No. B-40 of the Conselho Nacional do Petróleo, Mata São João, Brazil. Not positively identified in the other collections.

Subgenus PARACYPRIDEA Swain, n. subgen.

Subgenotype: *Cypridea* (*Paracypridea*) *obovata* Swain, n. sp.

Cypridea-like Ostracoda possessing an antero-ventral hood and postjacent notch or furrow, and having the hood more or less extended ventrally as a beak; differing from typical *Cypridea* in that the greatest height lies in a postmedian position, and the right valve overlaps the left.

Hingement simple, the otherwise unornamented hinge margin of the left valve faintly grooved to receive a corresponding narrow ridge on the hinge margin of the right valve. There does not appear to be overlap along the hinge. Muscle scar spots forming a group that lies slightly anterior to midlength and dorsal to midheight, and consists, in the subgenotype, of a posteriorly-curved row of four spots together with two slightly more posterior spots. Inner lamellae not coinciding with inner surface; very narrow along the ventrum, becoming broader terminally, and broadest anteriorly.

Occurrence.—Known at present only from a surface exposure of the Bahia beds, Aratú, Quadrangle 30, Section H, Bahia Province, Brazil; questionably uppermost Jurassic or lowermost Cretaceous in age.

CYPRIDEA (PARACYPRIDEA) OBOVATA
Swain, n. sp.
Plate 83, figures 14, 15; text-figure 1a

Shell elongate-ovate in lateral aspect; greatest height slightly less than one-fourth distance from posterior end. Hinge margin straight and a little less than one-half shell length. Anterior end rounded, rather more extended below, somewhat truncate above. Posterior end more broadly rounded, slightly extended below in the holotype, a separated left valve, but in some other specimens the greatest extension is above. Ventral margin somewhat sinuous, although in broader aspect it is nearly straight to slightly convex. At the antero-ventral marginal bend there is an inconspicuous hood together with a postjacent, better-defined, narrow furrow or notch; the hood is more or less produced ventrally as a short beak. Greatest convexity slightly posterior to midlength.

Right valve slightly larger than left and overlapping it except dorsally; overlap greatest ventrally, rather inconspicuous terminally. Surface smooth. Internal features are as described for the subgenus.

Dimensions.—Length of holotype, a separated left valve, 1.37 mm., height 0.78 mm.

Holotype.—U. S. Nat. Mus. 103846.

Relationships.—This does not seem to be closely related to any described species. One example of *Cypridea piedmonti* (Roth) from the Morrison formation of South Dakota (see Harper and Sutton, 1935, pl. 76, fig. 13) atypically has the anterior end strongly extended, and appears to have the cyprideid hood and furrow, features not evident in other representatives of the species. Even with its extended anterior end, however, the greatest height of the Morrison example lies anterior to midlength, not posterior to this position as in *C. (P.) obovata.*

Occurrence.—Known only in a surface collection from the Bahia beds labeled Aratú, Quadrangle 30, Section H, Bahia Province, Brazil, donated by the Conselho Nacional do Petróleo.

Genus METACYPRIS G. S. Brady, 1870
METACYPRIS POSTANGULARIS
Swain, new species
Plate 84, figures 1–8, 13, 14

Shell oblong-subquadrate in lateral outline; hinge margin nearly straight and slightly more than one-half shell length. Anterior end the more narrowly rounded most extended below. Anterior cardinal angle very obtuse; posterior cardinal angle prominent and much less obtuse than the other. Ventral margin nearly straight to somewhat convex. Left valve slightly larger than right.

A shallow, broad, dorsomedian sulcus lies about two-fifths from the anterior end; it dies out just dorsal to midheight, and is bounded anteriorly by a broad, poorly-defined lobe; a second, inconspicuous, oblique sulcus lies anterior to the lobe. A narrow marginal rim occurs along the anterior end. Surface pitted coarsely and in a reticulate fashion; along the ventrum the longitudinal elements of the reticulum are stronger. The interspaces between the pits average over one-half the width of the pits.

Greatest convexity posterior in position. The specimens at hand indicate clearly that dimorphism occurs in the species; certain examples, including the holotype, are much swollen posteriorly, and are presumably females; other examples, although most convex posteriorly, are much less swollen, and presumably are males.

Hingement not clearly observed, as no separated valves are at hand, but viewed by transmitted light, the hinge, in several specimens, does not appear to have terminal teeth or sockets. Muscle scar consists of a subvertical row of four closely spaced spots. The individual muscle spots consist of an elevation on the inner valve surface that is bounded by a narrow furrow. The scar lies ventral to the dorsomedian sulcus, and is slightly ventral to midheight.

Dimensions.—Length of holotype, a complete female example, 0.89 mm., height 0.51 mm., thickness 0.50 mm.

Holotype.—U. S. Nat. Mus. 103847; paratypes, 103848, 103849, 103850.

Relationships.—This species is clearly congeneric with other described Jurassic and early Cretaceous examples of *Metacypris*, in that it is a straight-backed, sulcate, and reticulate form, with a type of dimorphism characterized by varying obesity of the shell posterior to the dorso-median sulcus. The writer feels that generic identity of the

Mesozoic representatives of *Metacypris* with the genotype, *M. cordata* Brady, from the Recent of England, has not been adequately demonstrated owing to lack of complete information about the internal characters of both the Mesozoic and the Recent forms. Because of rather close similarity to *M. cordata* in outward appearance, and lacking specific evidence for their separation from that genus, it seems best, for the present, to continue to refer the described Jurassic and early Cretaceous species to *Metacypris*.

In *M. postangularis* the pattern of the adductor muscle scar consists of a subvertical row of four small spots. Inasmuch as *Metacypris* has been assigned to the family Cyprideae, in the typical representatives of which the muscle scar pattern is formed of a varying number of spots roughly arranged in a subcircular fashion, the familial relationships of *M. postangularis* and related species becomes subject to question. Until some standard of characters, based on hard parts, has been introduced for the various post-Paleozoic ostracode families, the position of the metacyprids will remain uncertain. In the Cytheridae the muscle scar is formed by a subvertical row of three or four spots, but at least typically there are in addition one or two more anterior spots. Thus while the main part of the muscle scar of *Metacypris postangularis* is cytheridiid in character, it may be suggested that in the Cytheridae the functional stability requiring the more anterior muscle attachments resulted in an anatomy fundamentally different from the one which did not need these more anterior muscle strands.

M. postangularis differs from most other described species in having a very pronounced and only scarcely obtuse posterocardinal angle. *M. ventrosa*, n. sp. has a more impressed and expanded ventrum, and deeper, narrower sulci. In its weak sulcation, the species under discussion is close to *M. forbesii* Jones from the Middle Purbeck of England, but the latter has a compressed anterior end, a more obtuse posterocardinal angle, and finer surface reticulation. As compared to the Upper Jurassic Morrison species *M. pahasapensis* (Roth) and the Lower Cretaceous species from the Bear River, Peterson and Kootenai formations, *M. persulcata* Peck and *M. angularis* Peck, all from the Rocky Mountain region, the species under discussion is much more weakly sulcate.

Occurrence.—Very abundant in shale sample from core No. 62 at 4893 feet, well No. B-40, Mata São João, Brazil; also present in core No. 69 at 5693–5702 feet but not observed with certainty below this, depth; surface collection, Bahia beds, Aratú, Quadrangle 30, Section H, Bahia Province, Brazil.

METACYPRIS POSTANGULARIS var. INORNATA Swain, n. var.
Plate 84, figures 9, 10

Like *M. postangularis*, n. sp., but having the valve surfaces smooth except for weak pustule-like elevations that appear to mark the external openings of the pore-canals.

Dimensions.—The holotype, a female example, measures: length 0.89 mm., height 0.54 mm., thickness 0.51 mm.

Holotype.—U. S. Nat. Mus. 103851.

Occurrence.—The new variety is found fairly commonly in company with *M. postangularis* in a sample of greenish-gray shale from core No. 62 at 4893 feet, well No. B-40 of the Conselho Nacional do Petróleo, Mata São João, Brazil.

METACYPRIS VENTROSA Swain, n. sp.
Plate 84, figures 11, 12, 15, 16

Shell oblong-subquadrate in lateral outline; hinge margin nearly straight and slightly less than two-thirds shell length. Anterior end the more narrowly rounded, most extended below; posterior end more broadly rounded and somewhat truncate in its middle portion as viewed laterally. Antero-cardinal angle very obtuse; posterocardinal angle prominent, much less obtuse. Ventral margin nearly straight to slightly concave. Left valve slightly larger than right.

A narrow, dorso-median sulcus lies about two-fifths from anterior end; it dies out approximately at midheight, and is bounded anteriorly by a lobe; a second, narrow, oblique and shorter sulcus lies anterior to the lobe. Surface reticulately pitted; on the ventral slopes the longitudinal elements of the reticulum are stronger; the interspaces between the pits average about one-third

the width of the pits. Ventrally the valve surfaces are rather strongly produced and expanded so that the greatest convexity is ventral in position; in end view the outline is reniform-triangular; the edges of the valves are strongly impressed along the ventrum. The holotype, a specimen that is partially imperfect ventrally, is possibly a female.

Muscle scar consists of a vertical row of four, closely spaced, small pits, lying ventral to the dorso-median sulcus. Hingement and other internal features not observed.

Dimensions.—Length of holotype 0.79 mm., height 0.46 mm., thickness 0.46 mm.

Holotype.—U. S. Nat. Mus. 103852; paratype, 103853.

Relationships.—*M. ventrosa* is close to *M. postangularis* in lateral aspect, but has a more flaring and marginally impressed ventrum, and narrower, slightly deeper sulci.

Occurrence.—Known only from a sample of shale and shaly limestone, core No. 69 at 5693–5702 feet, well No. B-40 of the Conselho Nacional do Petróleo, Mata São João, Brazil.

METACYPRIS PAUCISULCATA
Swain, n. sp.
Plate 84, figure 17

Shell oblong-subquadrate in lateral outline; hinge margin slightly convex and about three-fifths shell length. Anterior end the more narrowly rounded, slightly more extended below; posterior end broadly and uniformly rounded; anterocardinal angle very obtuse; posterior cardinal angle less obtuse. Ventral margin nearly straight to scarcely concave; dorsal and ventral margins converge slightly toward the anterior. Left valve a little larger than right.

Surface inconspicuously bisulcate anterior to and dorsal to valve middle. Valves ornamented with reticulate pitting, in which the width of the interspaces is about one-half the width of the pits. Greatest convexity posterior to midlength. Internal structures unknown. The holotype and only known example is probably a female.

Dimensions.—Length of holotype 0.92 mm., height 0.48 mm., thickness 0.45 mm.

Holotype.—U. S. Nat. Mus. 103854.

Relationships.—In general shape, *M. paucisulcata* resembles *M. postangularis*, but is much more weakly sulcate, lacks the strong posterocardinal angle and the anteromarginal rim, has a slightly concave ventrum, and is somewhat larger.

Occurrence.—Known only from a surface collection labeled Aratú, Quadrangle 30, Section H, Bahia Province, Brazil.

METACYPRIS TODILTENSIS
Swain, n. sp.
Plate 84, figures 20–22

Shell elongate-oblong in lateral outline; dorsal and ventral margins nearly straight and subparallel; hinge about three-fifths shell length, Ends have about equal curvature and are provided with narrow, terminomarginal rims. Valves approximately equal in size.

A single, narrow, subvertical sulcus lies two-fifths from the anterior end; it extends nearly the full height of the valve but is constricted medially. Greatest convexity in posterior three-fifths; shell rather tumid. Valve edges not appreciably impressed ventrally. Surface finely pitted.

Hingement and other internal features unknown.

Dimensions.—Length of holotype, a specimen in which the right valve is imbedded in matrix, 0.65 mm., height 0.30 mm.; thickness of a paratype (plate 84, fig. 21) having same length as holotype, 0.35 mm.

Holotype.—U. S. Nat. Mus. 103855; paratypes, 103856.

Relationships.—The species under discussion is close to unisulcate representatives of *M. whitei* Jones (1886), from the Morrison formation of Colorado. Other examples of the latter species are illustrated as having an additional more anterior and much shorter sulcus. In the unsisulcate members of *M. whitei*, the sulcus is not shown to be constricted medially as in *M. todiltensis*, but in the bisulcate representatives it is apparently so constricted. Additional Morrison material should be studied, as it appears that *M. whitei* may include at least two distinct species.

Occurrence.—Todilto limestone member of the Morrison formation, about six miles north of Thoreau, New Mexico, on State highway 56; collected by R. H. Wilpolt, and J. B. Reeside, Jr.

METACYPRIS? TRINODOSA
Swain, n. sp.
Plate 84, figure 23

Shell oblong-elongate in lateral outline; hinge margin straight to scarcely concave, and about three-fifths shell length; ends have about equal curvature; ventral margin slightly convex.

Anterior margin bears a well defined rim; posterior margin of holotype and only example preserving external features, only questionably bears a rim; ventrally a faint, very narrow rim is visible. About two-fifths distance from anterior end, the surface bears a shallow, dorso-median, subvertical depression or sulcus. Anterior to sulcus is a low median elevation; posterior to sulcus there are two small elevations, one just dorsal to midheight, the other just ventral to midheight. Surface finely and reticulately pitted. Internal features unknown.

Dimensions.—Length of holotype, a posteriorly imperfect left valve affixed to matrix, 0.73 mm., height 0.38 mm.

Holotype.—U. S. Nat. Mus. 103857.

Relationships.—With its straight-backed, sulcate shell, this species appears to be closely allied to *Metacypris*, but only the holotype, an incomplete left valve, and an internal mold of an additional left valve have been obtained, so that for the present, its assignment to the genus remains tentative. Jones' species *Cypris? conculcata*, from the Bahia beds, Montserrate Hill, has a well-defined marginal rim and a slightly concave ventrum, but has two dorso-median swellings and exhibits marked convergence of the dorsal and ventral margins.

Occurrence.—Obtained from a sample of core No. 69 at 5693–5702 feet, well No. B-40, Mata São João, Brazil.

FAMILY DARWINULIDAE Brady and Robertson
Genus DARWINULA Brady and Robertson, 1872
DARWINULA cf. D. DAKOTENSIS
Harper and Sutton
Plate 84, figure 18

Darwinula dakotensis Harper and Sutton, 1935, Jour. Paleontology, vol. 9, no. 8, p. 623, pl. 76, figs. 1, 2.

Shell elongate-subreniform in lateral outline; dorsal margin strongly convex, the greatest height lying slightly posterior to midlength; anterior end narrowly rounded; posterior end somewhat less narrowly rounded; ventral margin nearly straight, but slightly concave postmedially. Right valve scarcely larger than left. Surface smooth; valves only moderately convex.

Internal features not clearly observed, but hingement as viewed by transmitted light appears simple; muscle scar not seen.

Dimensions.—The figured specimen measures: length 0.56 mm., height 0.28 mm., thickness 0.19 mm.

Figured specimen.—U. S. Nat. Mus. 103858.

Relationships.—The Bahia examples appear to be very close to *D. dakotensis*, from the Morrison formation of South Dakota. Harper and Sutton have mistakenly described the straight margin as dorsal, although as figured, the more convex margin is correctly placed upward. As compared to *D. leguminella* Jones, the species under discussion is less elongate, and higher, with the dorsum more strongly arched. *D. allportina* (Jones), from the Bahia beds, is somewhat more elongate, as figured by that author (1860, pl. XVI, fig. 16).

Occurrence.—Common in a shale sample from core No. 62 at 4893 feet, well No. B-40, Mata São João, Brazil; rare in core No. 69 at 5693–5702 feet.

DARWINULA DAKOTENSIS MICROSTRIATULA Swain, n. var.
Plate 84, figure 19

Shell like that of *D. dakotensis* Harper and Sutton, but valve surfaces bear very fine, longitudinal striae.

Dimensions.—Length of holotype 0.56 mm., height 0.30 mm., thickness 0.15 mm.

Holotype.—U. S. Nat. Mus. 103859.

Relationships.—Inasmuch as these finely striate forms occur, so far as presently known, only in association with the more abundant, smooth *dakotensis*, they are here treated as a variety rather than a distinct species.

Occurrence.—Fairly common in shale sample from core No. 62, 4893 feet, well No. B-40, Mata São João, Brazil.

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JOURNAL OF PALEONTOLOGY, VOL. 20, NO. 6, PP. 556–559, PL. 85, NOVEMBER 1946

MIDDLE PERMIAN CEPHALOPODA FROM TEXAS AND NEW MEXICO

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ABSTRACT—Some Middle Permian Cephalopoda are noted from newly-discovered occurrences at localities in Texas and New Mexico. The species, none of which is new, are of interest to paleontologists and stratigraphers concerned with lithogenetic and time-stratigraphic relationships for the Middle Permian in America.

ON OCCASIONS since 1942, the writer has studied Permian structure and stratigraphy at a number of outcrop localities in Texas and New Mexico. The geological investigations, primarily related to the development of oil and gas reserves, led to the discovery of new occurrences for some critical Middle Permian Cephalopoda that have been described for the genera *Pseudorthoceras*, *Medlicottia*, *Pseudogastrioceras* and *Perrinites*. These Cephalopoda of wide stratigraphic ranges, are important in defining a number of lithogenetic and time-stratigraphic zones in the Middle Permian of America.

Middle Permian Cephalopoda, discovered at new localities in Texas and New Mexico, include the following species:

Pseudorthoceras splendens Clifton
Medlicottia burkhardti Böse
Pseudogastrioceras roadense (Böse)
P. beedei (Plummer and Scott)
P. texanum Clifton
Pseudogastrioceras sp.
Perrinites hilli (Smith)

The nautiloid *Pseudorthoceras splendens*, originally identified in strata of the Blaine and the Dog Creek formations in north central Texas, is found in the South Wells limestone member of the Cherry Canyon formation in the Delaware and the Guadalupe mountains, Texas. This nautiloid is identified in strata of the San Andres group in New Mexico, at several localities in the Sacramento Mountains near Cloudcroft, and along the Rio Penasco. Two specimens were collected at a locality in Last Chance Canyon about one mile northwest of Sitting Bull Falls, Eddy County, New Mexico, in strata that are doubtless time-stratigraphic equivalents (Clifton, 1945) of part of the San Andres group.

Ammonoids of the genus *Pseudogastrioceras* are recognized at critical localities, in Texas and New Mexico. Sympatric forms in this genus were transbasin in distribution, though doubtless transocean in origin to Middle Permian seas, since their distribution, so far as the writer has been able to determine, is restricted in Middle Permian deposits to strata no older than the Word formation of the Glass Mountains, the Cherry Canyon and Bell Canyon formations in the Delaware and Guadalupe mountains, the Blaine and Dog Creek formations, in Texas, and in strata of the San Andres group, New Mexico. In such Middle Permian deposits, excepting the Cherry Canyon and the Bell Canyon formations, *Pseudogastrioceras* occurs with *Perrinites hilli*. Significantly, *Pseudogastrioceras* has not been noted by the writer in strata of the type Leonard or in the Bone Spring formation in Texas.

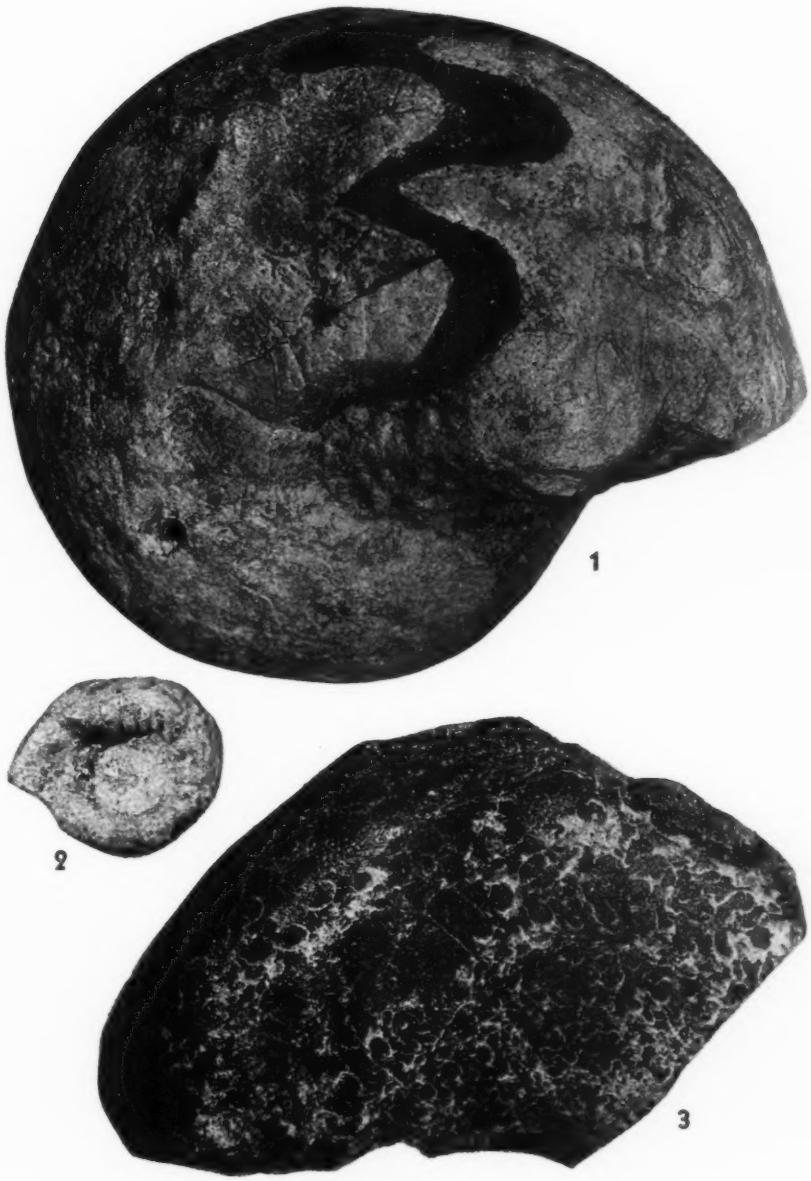
Sympatric forms of both *Pseudogastrioceras* and *Waagenoceras* appear abruptly in strata of the Cherry Canyon formation of the Delaware and the Guadalupe mountains

EXPLANATION OF PLATE 85

The figured specimens are deposited at the State University of Iowa.

FIGS. *1*, *2*—*Pseudogastrioceras roadense* (Böse). *1*, A large phragmacone, ×1, from Dog Creek formation, six miles north of Aspermont, Texas; *2*, a juvenile specimen, ×1½, from the Dog Creek formation, same locality. (p. 558)

3—*Perrinites hilli* (Smith). Part of a phragmacone 108 mm. in diameter, ×1, from the top of the San Andreas group, 37 miles west of Artesia, New Mexico. (p. 558)



Clifton, Middle Permian Cephalopods

and in the Word formation of the Glass Mountains, Texas. Thus characterized by abrupt appearance in Middle Permian seas, they initiate paleontologically a time-stratigraphic division or a *stage* of the Middle Permian in America, which can be defined by subsequent distribution of these ammonoids in the stratigraphic succession. However, *Waagenoceras* is not known from north central Texas or from New Mexico. *Pseudogastrioceras*, of wider lateral distribution, has not been identified in north central Texas nor in Oklahoma, in strata of the Whitehorse group of the Upper Permian.

The ammonoid *Perrinites hilli*, an excellent zone fossil for the Middle Permian (Plummer and Scott, 1937), is identified in uppermost strata of the San Andres group in New Mexico, where its occurrence represents the highest known stratigraphic range for this ammonoid in America. At this locality, the writer collected three moderately large specimens. *Perrinites hilli* has been identified in strata of the lower Word (Clifton, 1945), where the occurrence of this genus transcends the *type* Leonard of the Glass Mountains, Texas.

This species is found in the Leonard and the Guadalupe series, two time-stratigraphic nomenclatural units, that were erected partly on the criteria of *Perrinites* distribution, restricted as then understood (Adams et al., 1939), to strata no younger than the *type* Leonard of the Glass Mountains, Texas. It is now known that *Perrinites hilli* did not become extinct before the appearance of *Waagenoceras* in Middle Permian seas.

Most of the ammonoids discussed on the following pages have been studied by various authors and extensive synonymies have accumulated for them. Since these synonymies have been listed in recent publications by Plummer and Scott (1937), Miller and Furnish (1940), and Miller (1944), the writer does not include them in this paper.

Pseudorthoceras splendens Clifton

Pseudorthoceras splendens Clifton, 1942, Jour. Paleontology, vol. 16, no. 6, p. 694, pl. 102, figs. 1, 2; pl. 103, fig. 1.

This species is represented in the writer's collections by many specimens from widely-separated localities in Texas and New Mexico. The specimens, most of which are poorly preserved, can be identified by shape of the phragmacone, septal divisions, position of the siphuncle with respect to the long axis of the phragmacone and by characteristic deposits within the camerae.

Pseudorthoceras splendens is distinguished from older Permian and Pennsylvanian forms by the morphology of the siphuncle and siphuncular areas. The holotype and paratypes exhibit a cylindric central tube or inner siphonal wall and an outer or subspherical wall for the expanded segments of the siphuncle after passage through the septal walls.

Occurrence.—*Pseudorthoceras splendens* is identified in strata of the Pease River (El Reno) group in north central Texas. Two specimens were collected from the South Wells limestone member of the Cherry Canyon formation at a locality about three miles northeast of Pine Spring Camp, Guadalupe Mountains, Texas. A number of specimens were collected from strata of the San Andres group at localities in New Mexico.

Medlicottia burkhardti Böse

This species was described by Böse from the Word formation of the Glass Mountains, Texas. *Medlicottia burkhardti* is closely related to *M. whitneyi* Böse, with which it is associated in strata of the Blaine, the Dog Creek and the Word (Miller, 1945) formations, Texas. As pointed out by Miller (1944), this species has few characteristics that distinguishes it from *M. whitneyi*. However, *M. burkhardti* is larger, some specimens in the writer's collections from the Blaine and the Dog Creek formations, being 110 mm. or more in diameter. Denticulate markings on the ventral zone and on ventrolateral keels distinguish *M. burkhardti* from *M. whitneyi*.

Occurrence.—The species is found in the lower Word formation of the Glass Mountains, Texas, where *Perrinites hilli*, *Pseudogastrioceras texanum* and *Waagenoceras dieneri* Böse also occur. *Medlicottia burkhardti* is found in strata of the Cherry Canyon formation, Delaware and Guadalupe Mountains, Texas. This species occurs in the Blaine and Dog Creek formations of north

central Texas, where it is commonly associated with *Perrinites* and *Pseudogastrioceras* at some localities.

PSEUDOGASTRIOCERAS ROADENSE (Böse)
Plate 85, figures 1, 2

This species is identified by the shape of its phragmacone and by the number of longitudinal lirae that mark the surface of the conch. The ornamentation on the umbilical region and the pattern of the suture line also distinguish it from congeneric forms *P. texanum*, *P. beedei*, *P. altudense* (Böse) and *P. serratum* (Girty).

Occurrence.—Two specimens of this species were collected from strata of the Dog Creek formation, at a locality in Section 137, Block D, H & T C R R Co., six miles north of Aspermont, Stonewall County, Texas, where *Pseudorthoceras splendens*, *Medlicottia whitneyi*, *M. burkhardti*, *Pseudogastrioceras texanum* and *Perrinites hilli* also occur.

Figured Specimens.—Deposited at the State University of Iowa.

PSEUDOGASTRIOCERAS TEXANUM Clifton

Pseudogastrioceras texanum Clifton, 1942, Jour. Paleontology, vol. 16, no. 6, p. 697, pl. 103, figs. 11, 12; pl. 104, figs. 1–6.

The holotype of this species was described from the Acme member of the Blaine formation in north central Texas. This species is identified in the Word formation. A single poorly preserved specimen was collected from the Word first limestone member at a locality near the top of the ridge, on the northwest side of the road about one-half mile southwest of the old Word Ranch house, 17 miles north-northeast of Marathon, Texas. It is also found in the Manzanita limestone member of the Cherry Canyon formation (Clifton, 1944), the Delaware and Guadalupe Mountains, Texas, and in the Dog Creek formation, Stonewall County, Texas. This species is very closely related to *P. serratum*, a form that is described from the Cherry Canyon formation of the Guadalupe Mountains and from the Word formation, of the Glass Mountains, Texas.

PSEUDOGASTRIOCERAS BEEDEI
(Plummer and Scott)

This species is identified in the Cherry Canyon and Bell Canyon formations of the Delaware and Guadalupe Mountains, Texas. The writer collected a single specimen from a stratum at the top of San Andres exposures, in an old railroad cut one-half mile northeast of Cloudcroft, New Mexico. This specimen is part of a weathered phragmacone about 80–90 mm. in diameter, on which there are preserved ventral and lateral areas that exhibit longitudinal lirae and a part of the suture line, which distinguish this species.

PSEUDOGASTRIOCERAS sp.

The writer collected a poorly preserved specimen of *Pseudogastrioceras* that cannot be specifically identified. It came from a stratum in the San Andres group about 800 feet above the base of the limestone section near the top of a prominent hill about six miles east of Pinon, in Section 28, T. 19 S., R. 16 E., Chaves County, New Mexico. The generic identification is based on part of the suture line, and faint markings of longitudinal lirae, that are preserved on a small ventral-lateral area of the broken conch.

PERRINITES HILLI (Smith)
Plate 85, figure 3

This ammonoid is found in uppermost outcrops of the San Andres group at a locality 37 miles west of Artesia, New Mexico. Earlier, J. W. Beede collected a single *Perrinites* specimen from a much lower San Andres stratum, at a locality west of Cloudcroft, New Mexico. The *Perrinites* specimens from these localities are identical and they cannot be distinguished specifically from *Perrinites* found in the Pease River (El Reno) group in Oklahoma and north central Texas.

Occurrence.—*Perrinites hilli* is widely distributed in deposits of the Middle Permian in America. This critical ammonoid is identified in strata of the Blaine and the Dog Creek formations, in Oklahoma, and in north central Texas; in the type Leonard and the lower Word formations of Glass Mountains; in Middle Permian deposits at localities in Hudspeth and Presidio counties, Texas; in strata of the San Andres group at two localities in New Mexico; and in Mexico.

Perrinites hilli was collected at a locality 37 miles west of Artesia, in Section 4, T. 17

S., R. 19 E., Chaves County, New Mexico, in strata of the San Andres group about 800 feet above the base of the San Andres limestone section and about 100 feet below the base of the Whitehorse group of the Upper Permian.

Figured Specimen.—Deposited at the State University of Iowa.

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THREE NEW FORAMINIFERA FROM THE TERTIARY OF ECUADOR

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ABSTRACT—Three new species of arenaceous Foraminifera are described from Tertiary formations of Ecuador: *Technitella* archaeonitida, *Planulina wheeleri*, and *Palmerinella thalmanni*.

THE wealth and variety of the foraminiferal faunas of the Ecuador Tertiaries are not adequately indicated in the published literature. Pending the opportunity to compile more comprehensive papers, we present here descriptions of three outstandingly interesting forms encountered in the course of zonational studies. This paper is published with the kind permission of the directorate of International Ecuadorean Petroleum Company. We gratefully express acknowledgment to Dr. J. A. Cushman for technical advice and assistance with the illustrations, to Dr. H. E. Thalmann for comments on the specimens, to Dr. Brooks F. Ellis for supplying photostat copies of obscure references, and to Mr. K. W. Barr for transcribing some early references to *Technitella*. Reliance has been placed on the "Catalogue of Foraminifera" by Ellis and Messina (1940) for all references to original type descriptions.

Family SACCAMMINIDAE
Subfamily PELOSININAE
Genus TECHNITELLA Norman 1878

Type-species: *T. legumen* Norman 1878, earliest species, first citation by Cushman 1910.

The arenaceous foraminiferal genus *Technitella* is rarely mentioned in current literature as almost without exception the known species have been described from Recent material. A few decades ago, when microscopy was the hobby of men of leisure and the results of oceanographic cruises such as those of the "Challenger" were widely publicized, the genus received considerable notice because of the outstanding elegance of the tests made by its different species. Later Heron-Allen emphasized the remarkable selective powers and constructive skill shown by the genus as evidence of some form of intelligence in the Protozoa. Typical of his attitude is the following extract from a paper (1915) which excited lively discussion:

> The intelligence which, I am bold enough to claim, is displayed by the arenaceous Foraminifera in their house-building takes two forms: first the exclusive selection of certain materials, and second, the manner in which they were used. The exclusive selection of Echinoderm plates by *Technitella thompsoni* Heron-Allen and Earland, for the construction of its test, is a most remarkable illustration of this selective power, for in neither of the dredgings in which it has been found do echinoderm plates such as are used in its construction abound. . . . The genus *Technitella*, as the name "Little Workman" implies . . . supplies us with one of the most remarkable illustrations of purpose and intelligence hitherto encountered in the Foraminifera. The most familiar species of the genus, *Technitella legumen* Norman, constructing its test only of spongespicules selected from the mass of mud, sand, molluscan and foraminiferal debris in which it lives, builds its shell wall in two layers, the outer one set parallel to the long axis of the shell, the inner one at right-angles to it. As we observed when we first discovered this feature, "we thus get as close an approximation to woof and warp as is possible in a rigid non-flexible material, and it is obvious that the strength of the test must be enormously increased by the crossing of the two layers. . . ." In the papers to which I have referred . . . it is shown that there is as wide a range of skill displayed by the Foraminifera both in choice of material and in actual construction as by builders in the higher scales of life, not even excepting man.

There seem to be only two references to *Technitella* in the fossil state, both from Mesozoic rocks in Europe. In the earlier of these Rychlicki (1912) records, without comment or figure, "Ein Stück von *Technitella raphanus* Brad." from the Upper Senonian of Leszcyzny in the Carpathians. The second reference is by Pfender (1938) to an organism studied in sections of Valanginian limestone from Provence. This is a

dubious record, not confirmed by the single figure published. Pfender's own opinion is expressed thus:

"(Cette éspèce) . . . est encore plus malaisé à definir car il ne semble présenter que sous forme de débris: des filaments, de 15μ d'épaisseur généralement, étroitment juxtaposées en petits paquets épars. Cependant il ne s'agit certainement pas d'une Algue; je comparerais de préférence ces restes à des débris du test d'un Foraminifère tel que *Technitella legumen* Norman 1878. . . .

The type description of the genus is:

Test elliptical, cylindrical or subfusiform, composed of broken fragments of sponge spicula arranged parallel to the axis and enclosed entirely, or rarely only partially, in the body wall. Unattached below and closed. A tubular mouth-opening formed by contraction for a short distance of the body walls so as to form a short tube.

Later authors have treated some of these features as of merely specific rank. As generic characters, emphasis has been laid on a high degree of selectivity in the material of the test and an unusual precision of construction, Most, but not all, of the described species are constructed of sponge spicules.

TECHNITELLA ARCHAEONITIDA
Stainforth and Stevenson, n. sp.
Plate 86, figures 1–3

This species is ellipsoidal and in its usual flattened state of preservation appears from 1½ to 3 times as long as broad. The holotype measures 1.25 ×0.69 mm.; associated specimens range in length from 0.56 to 1.50 mm. and in breadth from 0.22 to 0.77 mm. The test is made of closely spaced sponge spicules set parallel to the long axis in a minimum of non-calcareous cement. The diameter of the spicules chosen varies from one specimen to another, but it is usually uniform in any one specimen. Tests made of very fine spicules predominate. The small aperture is terminal, a simple circular opening formed by the ends of spicules neatly arranged to lie flush with one another. The aboral end is equally neatly made, either with long spicules forming a point or with a few fragmentary ones fitted into the smooth contour of the test. Examnation of thin sections and broken specimens failed to reveal any layer of transverse spicules such as was shown by Heron-Allen and Earland to be typical of *T. legumen* Norman.

Affinities and differences.—The species here described differs from *T. asciformis* Pearcey (1914) and *T. legumen* Norman (19—) in its lack of an apertural neck; from *T. hystrix* Chapman and Parr (1937) and *T. melo* Norman (19—) in its smooth contour compared with their echinate forms; from *T. mestayeri* Cushman (1919) and *T. raphanus* Brady (1884) in being ellipsoidal in contrast to their elongate, almost tubiform shape; from *T. bradyi* Earland (1934) in which the sponge spicules appear to be used almost adventitiously, in its higher degree of selectivity and neatness of construction; from *T. thompsoni* Heron-Allen and Earland (19—) in its construction of sponge spicules, not echinoderm ossicles, and likewise from the three species made of fine sand viz. *T. candida*, *T. flexibilis* and *T. globulus* Wiesner (23).

Of the described species this leaves only *T. nitida* Heron-Allen and Earland (1932), which shows little significant morphological difference from the Ecuador species. The holotype of *T. nitida* measured 1.5 ×0.8 mm., which compares closely with the larger specimens of *T. archaeonitida*. The type description of *T. nitida* specifies the presence only of longitudinally placed spicules and this is also true of the new species. *T. nitida*, however, is described as having "a large simple aperture surrounded by a slightly thickened and everted neck," and it definitely differs in this respect from *T. archaeonitida*, which has no neck. Another reason for considering the two species to be distinct lies in their relative ages. Though the Ecuadoran species is quite common in beds of Lower Oligocene age, no signs of it have been found in ecologically similar beds younger than Middle Oligocene, whereas *T. nitida* is only known as a recent form.

Occurrence.—In the Playa Rica formation as described by Olsson (1942), which includes Upper Eocene to early Middle Oligocene beds. It is most frequent in the younger part of the formation. The holotype was collected from sample I.E.P.C. No. 17117 at the confluence of the Estero Tumbavero tributary with the main stream of the Rio Zapallo Grande, some 3 Km. E.S.E.

from the village of Telembi on Rio Cayapas in northwest Ecuador. The geographic coordinates of the type locality are 00° 47′ 43″ North: 78° 54′ 21′ West.

Type material.—The holotype is deposited at the Cushman Laboratory for Foraminiferal Research, in Slide No. 45587. In the same collection Slide No. 45586 contains the other figured specimens and Slide No. 45588 contains topotype material. Other topotypes have been forwarded to the following institutions: American Museum of Natural History; Colorado School of Mines; Walker Museum, University of Chicago; Stanford University; British Museum of Natural History.

Family ANOMALINIDAE
Subfamily ANOMALININAE
Genus PLANULINA d'Orbigny 1826
Genotype *P. ariminensis* d'Orbigny, 1826.

This is the usually accepted classification, taken from Cushman's textbook (1940). Galloway (1933) refers the genus to the Family Rotaliidae Reuss 1860; Subfamily Cibicidinae Galloway 1933; genus and genotype as above. More recently Brötzen (1942) has offered an interesting re-classification of the rotaliiform Foraminifera, in which *Planulina* is referred to the Family-group Rotaliiformes; Family Valvulineriidae; Subfamily Cibicidinae; genus and genotype as before.

PLANULINA WHEELERI Stainforth and Stevenson, n. sp.
Plate 86, figures 4–6

Description.—Shell vitreous, very finely perforate. General shape compressed, almost discoidal. Initial portion trochoid, later becoming evolute and almost planispiral. Chambers 13 to 20 in the final whorl, sutures recurved, chambers slightly inflated along the sutures. On the dorsal side the small circular nucleoconch is faintly discernible, tightly coiled, though uncoiling is so rapid that in most adult specimens the inner edge of the final whorl barely overlaps the previous coil. On the ventral side only the chambers of the final whorl are visible, surrounding a small circular umbilical pit which tends to be accentuated by a low rim of clear shell material. The outline is undulose and not a precise spiral, its irregularities coinciding with variations in chamber-breadth. The diameter of the holotype is 1.15 mm. and its median thickness 0.28 mm.

The aperture appears to be a very fine crescent-shaped slit at the base of the apertural face, possibly running back along the spiral suture under the last three or four chambers. Despite having examined about two hundred specimens we have not found one in which the aperture is clearly visible. The above description is based on the composite impression gained by the examination of many specimens, and is supported by thin-section studies. Some of the broken specimens show what appears to be an apertural pore at the outer tip of the apertural face, but unbroken specimens do not show this feature, nor is it apparent in any of the thin-sections.

Comments.—On first inspection we were inclined to believe that this species belonged to a new genus of the Anomalinidae, but on detailed examination it could not be separated with certainty from *Planulina*. It is a peculiar species, possibly modified for life in a littoral facies.

This species seems most properly referred to *Planulina* on the principal morphological features of the test, especially the form of coiling and the aperture. We have failed, however, to find any described species of *Planulina* with so finely perforate a test, so many chambers, or such an obscure aperture.

The species is named for O. C. Wheeler, director of International Petroleum Company, Toronto.

Occurrence.—The holotype is from calcareous sandstones outcropping in bluffs immediately south of the village of San Pedro, about 40 Km. (not miles as stated by Barker) northeast of Santa Elena point in southwest Ecuador. Geographic coordinates of the type locality are 01° 57′ 03″ South: 79° 53′ 37″ West This locality has been mentioned in the literature by Barker (1932) as the provenance of *Miogypsina* aff. *panamensis* Cushman, later re-described as *Miogypsina* (*Miolepidocyclina*) *ecuadoriensis* Tan (1936). Barker gave the age of the deposits as Aquitanian-Burdigalian. (Above references *fide* Thalmann (1945.) Currently the age of the San Pedro sandstones is considered to be Upper Oligocene.

The species is common in fossiliferous parts of the sandstones at the type locality. It was also found commonly in a lenticle of foraminiferal sand cored in a well near Bajada in southwestern Ecuador—age of this occurrence low in the Upper Oligocene. It is noteworthy that the species was completely absent from the shales in which this lenticle of sand was included, and the inference may be drawn that the species prefered a littoral environment.

Type material.—The holotype of the species has been deposited in the Cushman Laboratory for Foraminiferal Research in Slide No. 45583. Topotypes have been deposited in the same collection in Slide No. 45582 and also in the following institutions: American Museum of Natural History; Colorado School of Mines; Walker Museum, University of Chicago; Stanford University; British Museum of Natural History. Also specimens from the Bajada well have been deposited in the Cushman collection in Slides Nos. 45593, 45594.

Family ANOMALINIDAE
Subfamily ANOMALININAE
Genus PALMERINELLA Bermudez 1934
Genotype *P. palmerae*
Bermudez 1934

The genus *Palmerinella* rests on a single species described from Recent beach sand in Cuba. On the evidence of the Ecuadorean species described below we are able to extend the geological range of the genus back into the basal Miocene, and to amend the original description.

Description of genotype.—(translation):

Shell in the form of a very low spiral, initial chambers visible from the dorsal side and also from the ventral side through a thin umbonal deposit. Wall vitreous, calcareous, somewhat coarsely perforate. Elongate aerture in the face of the last chamber, outlined, except at the base, by a distinct collar.

This new genus is a modification of the evolute genus *Anomalina*, approaching in its manner of growth to the genus *Planulina*, but slightly trochoid. The characteristic which distinguishes it is the oval elongate aperture in the septal face, surrounded, except at the base, by a distinct collar.

On the evidence of the species described below two modifications should be made in the definition of the genus. First, the wall may be finely perforate; Bermudez' descriptions were slightly contradictory since he described the genotype as "algo toscamente perforada" but the type species as "finamente pero conspicuamente perforada." Second, the initial chambers are not always visible from the ventral side.

PALMERINELLA THALMANNI Stainforth and Stevenson, n. sp.
Plate 86, figures 7–10

Description.—Small, vitreous to transparent, finely but plainly perforate. Composed of few chambers, usually 8 fully developed in the final whorl. All chambers visible on the dorsal side, only those of the final whorl on the ventral side. Two to 2½ whorls on the dorsal side. Sutures limbate and transparent, usually strongly raised between the early chambers, tending to become depressed between the final chambers. Strongly raised and slightly curved early sutures coalesce into the umbo and peripheral edge. Later sutures almost straight. Sutures of successive whorls tend to be in alignment. Periphery ranges from a square to a subacute edge. Aperture a narrow, parallel-sided to slightly tapering slit extending from inner to outer margin in center of apertural face. In younger specimens aperture is surrounded, except at the base, by a distinct collar, but in more mature specimens this feature tends to disappear. Entire apertural face rimmed by a raised extension of the peripheral edge. Umbonal plug usually strongly developed on dorsal side but absent or weakly developed on ventral side. Coiling is normally planispiral, though larger specimens tend to be trochoid. Coiling is normally sinistral on the dorsal side and dextral coiling is unusual. Diameter 0.20 to 0.30 mm., thickness 0.07 to 0.15 mm.

Variation.—Two hundred specimens chosen for this study exhibited the following variations: the umbonal plug may be strongly or weakly developed on both dorsal and ventral sides, or on the dorsal side alone, and it may be either opaque or translucent; raised limbate sutures may be strongly or weakly developed on both dorsal and ventral sides, on the dorsal side only, or the sutures may all be depressed; in some large specimens the last three or four chambers may be lobate at the periphery. Probably an environmental effect is the occasional ad-

dition of adventitious shell material in the form of secondary peripheral flanges, umbilical nodes and enlarged sutures.

Specimens of *P. palmerae* Bermudez from the Recent and Upper Miocene of Cuba and the Pliocene and Upper Miocene of the Dominican Republic, kindly sent to us by P. J. Bermudez, show a tendency to vary in similar respects.

Affinities and differences.—This new species is undoubtedly closely related to the only other described species, *P. palmerae* Bermudez, as shown by their similarity of general form and in particular their peculiar aperture. In specific features *P. thalmanni* n. sp. differs from *P. palmerae* in that the chambers of the former are fewer, shorter, straighter and broader; the dorsal side is less evolute; the sutures are usually more raised; and a more prominent umbonal plug and peripheral flange are present.

This new species is named for Dr. Hans E. Thalmann, with whom the writers had the pleasure of working when he was chief paleontologist of the International Ecuadorean Petroleum Company.

Occurrence.—Basal Miocene, Province of Manabí, Ecuador, from shale outcrops in gullied hillsides bordering the town of Charapotó on its north side. This town is located near the Pacific sea-coast in central Ecuador at 0° 50′ 14.7″ South latitude and 80° 29′ 31.2″ West longitude.

P. thalmanni is abundant throughout a shale formation overlying the "Manta shale" (late Middle Oligocene) the fauna of which was described by Galloway and Morrey (1929).

The genus *Palmerinella* was first recorded from Recent beach sand in Cuba. In a personal communication P. J. Bermudez informed us that the genotype also occurs in the Upper Miocene of Cuba and in the Upper Miocene and Pliocene of the Dominican Republic, in shallow water sediments. The new species here recorded from Ecuador extends the range of the genus downward into the base of the Miocene.

Type material.—Co-types have been deposited in the Cushman Laboratory for Foraminiferal Research, in Slide No. 45584 and in the same collection Slide No. 45585 contains the figured specimens. Topotypes have been sent to the following institutions: American Museum of Natural History; Colorado School of Mines; Walker Museum, University of Chicago; Stanford University, British Museum of Natural History.

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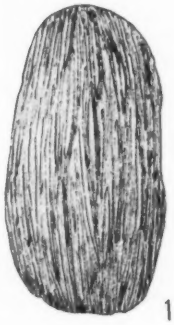
EXPLANATION OF PLATE 86

FIGS. *1–3—Technitella archaeonitida* Stainforth and Stevenson n. sp. *1*, Side view of holotype, ×30. Cushman Collection 45587. *2*, Apertural view of topotype, ×40. Cushman Collection 45586. *3*, Side view of another topotype showing construction of unusually thick sponge spicules, ×30. Cushman Collection 45586. All three specimens from the Lower Oligocene Playa Rica formation, northwest Ecuador. (p. 561)

4–6—Planulina wheeleri Stainforth and Stevenson n. sp. Holotype, ×30. Cushman Collection 45583. *4*, Ventral aspect, *5*, Peripheral aspect, *6*, Dorsal aspect. From Upper Oligocene San Pedro sandstone, southwest Ecuador. (p. 562)

7–10—Palmerinella thalmanni Stainforth and Stevenson n. sp. Co-types, Cushman Collection 45585. *7*, Dorsal aspect of a small specimen, ×75; *8*, Dorsal aspect, ×65. *9*, Peripheral aspect, ×75, and *10*, Ventral aspect, ×75, of a larger specimen. From Basal Miocene shale near Charapotó, west central Ecuador. (p. 563)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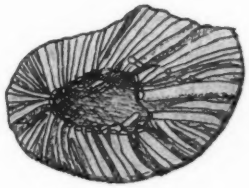
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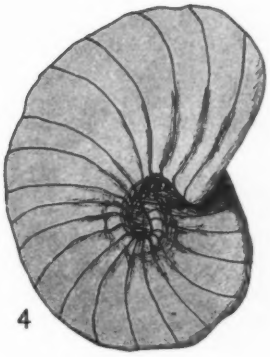
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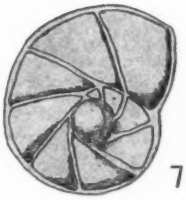
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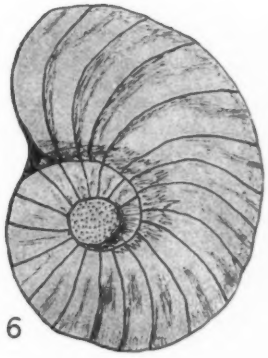
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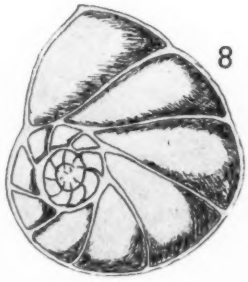
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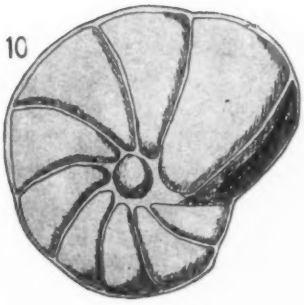
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JOURNAL OF PALEONTOLOGY, VOL. 20, NO. 6, PP. 566–569, 3 TEXT FIGS., NOVEMBER 1946

A CARAPACE OF THE ORDOVICIAN TRILOBITE TELEPHUS

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ABSTRACT—The various species of *Telephus* described to date are known only from very fragmentary remains. A unique specimen from the lower Athens formation (Chazyan) near Catawba, Virginia, referred to *T. spiniferus* Ulrich, consists of a virtually complete though somewhat disjointed carapace.

THE GENUS *Telephus* was established by Barrande in 1852. Various workers in later years added to our knowledge of these forms, particularly Hadding in 1913, and in 1929 Ulrich published a monograph on the family Telephidae.

Numerous species of *Telephus* have been described, all of them from Ordovician and possibly early Silurian beds in Bohemia, Scandinavia, Scotland, Ireland, and the Appalachian trough of North America. The descriptions are based on isolated cranidia, free cheeks, and, in some cases, pygidia. Isolated fragmentary thoracic segments of a few species have been found.

Since *Telephus* is known from fragments only, the discovery of a virtually complete carapace is of considerable interest. This carapace was found by Mr. F. L. Gaddy in the Athens shale near Catawba, Roanoke County, Virginia. The pygidium and thorax remain in articulation, and are somewhat compressed toward the left. The free cheeks have beeen slightly shifted, and the eyes crushed. The glabella has been overturned and carried forward, so that it now rests upside down and is longitudinally reversed.

The specimen has been deposited in the collections of the Department of Mining Geology, Virginia Polytechnic Institute, Blacksburg.

The writer is grateful to Dr. R. J. Holden, Department of Mining Geology, Virginia Polytechnic Institute, for help and advice during the course of this study, and owes a particular debt of thanks to Dr. Vance White, Department of Metallurgy, for permission to use his photographic laboratory. Thanks for help with the manuscript also go to Dr. W. H. Twenhofel and Dr. C. C. Branson.

Family TELEPHIDAE Angelin
Genus TELEPHUS Barrande
TELEPHUS SPINIFERUS Ulrich
Figures 1–3

Telephus spiniferus Ulrich, 1929, U. S. Nat. Mus. Proc., vol. 76, art 21, p. 29, pl. 3, fig. 11.

Ulrich described this species from a single cranidium found near the base of the Athens formation near Saltville, Virginia. Its outstanding features are the occipital crest and spine, the great forward extent and subtriangular shape of the fixed cheeks, and the fairly regular arrangement of the tubercles in anteriorly diverging rows on the median portion of the glabella.

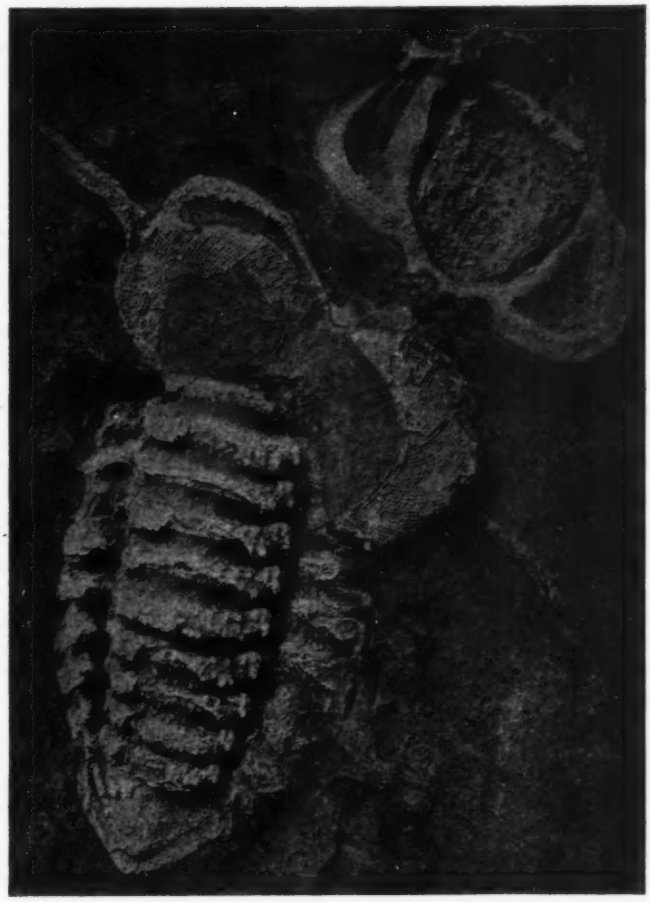
A rather similar cranidium found by Ulrich near the top of the Athens shale at Calhoun, Tennessee, was referred by him to a new variety. *T. spiniferous calhounensis*. It differs slightly from the Saltville

FIGS. *1–3*—*Telephus spiniferus* Ulrich, from the Athens formation, near Catawba, Roanoke County, Virginia. (p. 566)

1—Slightly retouched photograph, ×5.5. Cranidium at upper right, lying upside down. Note pustulose glabella, and slightly postulose subtriangular fixed cheeks, bordered by palpebral bands. A trace of the two small anterior cranidial spines characteristic of the genus may be seen near the center of the anterior margin. The free cheeks, in the center, show the marginal trough and cephalic rim on the left side, and the eyes as well as the blade like genal spines (in edge view) on both sides. Note edge of doublure connecting the free cheeks. The thorax at the lower left shows the long anterior flanges of the axial segments, with convex articulation rims, and the rather flat and highly pustulose axial rings. Note dorsal furrow on the left side of the pygidium.

2—Left free cheek, dorsal view, drawn, ×7.

3—Left free cheek, as seen from front and slightly above, drawn, ×7.



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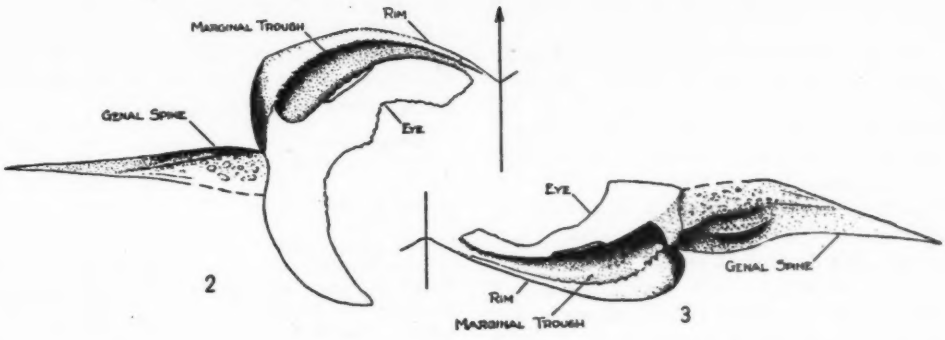
MARGINAL TROUGH
RIM
GENAL SPINE
EYE
2
EYE
GENAL SPINE
RIM
MARGINAL TROUGH
3

FIGS. 1–3

specimen in the shape of the glabella, and shows two shallow glabellar furrows.

The cranidium of the carapace found by Mr. Gaddy (fig. 1) does not show the glabellar furrows of var. *calhounensis*, but is structurally very close to Ulrich's holotype from Saltville, except in regard to occipital features. Ulrich's specimen shows a gentle crest and strong spine, whereas the specimen here described has a strong crest which terminates in a short blunt projection rather than a spine. As a true spine may have originally been present, but could have been lost during life or burial, it was decided to refer this carapace to *T. spiniferus* Ulrich, rather than to burden the literature with a new and perhaps invalid species.

The free cheeks are only partially exposed. The great crescentic eyes, elevated in life, have been flattened. The right one hides the lower structures of the free cheek except for part of the genal spine. The left eye leaves the anterior portions exposed, back to and and including the genal spine (figs. 2, 3). In front of the eye lies a trough, narrow at the inner corner, but widening gradually toward the genal spine. Outside of this trough lies a sharp rim, wirelike along the inner (reentrant) third, but widened laterally into a forward- and downward-sloping buttress, which before approaching the genal spine is abruptly inclined and is bent back sharply to meet the spine at an angle of 90°. The inner margin of this buttress bears a row of tubercles. Between the anterior corners of the eyes the cephalic rim is broken out, but the edges of the doublure may be traced across.

The genal spines, which vary considerably within this genus, are strikingly different from any heretofore described. They are blade-like structures, which stand on edge and project laterally, making a right angle with the longitudinal axis of the trilobite (figs. 2, 3). Each spine consists of a proximal, wide portion, with a slightly convex lower margin, grading into a slightly longer distal portion, in which both upper and lower margins are straight to slightly concave. The distal portion tapers gracefully to a sharp point.

Furthermore each spine is divided by a sharp edge or ridge, delicately curved, separating the main body of the blade from an upper facet, which slopes up and back. The ridge is strong near its origin but weakens distally and reaches the upper margin about two thirds of the way to the tip. Below this ridge slightly below the middle of the proximal portion of the spine, lies another, much shorter ridge. The proximal portion of the blade is liberally ornamented with small tubercles and granules, particularly well developed on the ridges. Distally they become sparse and very small.

The thorax (fig. 1) is composed of nine segments. Deep reentrant dorsal furrows divide the broad and prominent thororhachis from the relatively low and narrow pleural lobes, which unfortunately are poorly preserved. The thororhachis tapers gently behind the 3rd segment, and the pleura appear to taper sharply behind the fifth.

Longitudinally the axial portion of each segment shows an anterior flange and a posterior collar or ring. Each flange is deeply concave, with a slightly convex anterior articulation rim. The posterior rings are more or less fragmentary, but appear to be rather flat. Each bears numerous tubercles, particularly strong at its frontal and posterior margins.

In transverse aspect the rings are gently convex in the center. Toward the sides they become concave and swing forward, to form prominent shoulders on the margins of the reentrant dorsal furrows. Each of these shoulders bears two large tubercles on its anterior and one on its posterior margin.

Only imprints of the doublure and dorsal furrow of the pygidium remain. The furrow is present to a point about half way to the caudal end, but may have extended further. The shape of the pygidium is strikingly trigonal, somewhat wider than long.

Dimensions:		
Length cranidium	6	mm
Width	9	mm.
Length glabella	5	mm.
Width glabella	5	mm.
Length genal spine	5	mm.
Length thorax	10.5	mm.
Width thorax at 4th segment	9	mm. approx.
Width 3rd axial ring	5	mm.
Length pygidium	2	mm.
Width pygidium	3.5	mm.

Occurrence.—The specimen was found by Mr. F. L. Gaddy, on a collecting trip conducted by Dr. R. J. Holden and the author,

under the auspices of the Virginia Polytechnic Institute. It was collected at a conspicuous cut on Virginia State Highway 114, about 2.5 miles southwest of the junction of this road with Virginia State Highway 311, in Roanoke County, Virginia, approximately four miles southwest of Catawba Sanatorium.

The beds exposed here consist of hard, slabby, black shale. They clearly belong to the Athens formation, and appear to lie about 400 feet above its base. The slab in which the *Telephus* was found has yielded no other fossils, but adjacent beds contain graptolites and trilobites, including *Dicranograptus* sp., *Climacograptus scharenbergi* Lapworth, *Raphiophorus powelli* Raymond, and *Dionide* sp. Elsewhere, as at Lusters Gate, 3.4 miles east of Blacksburg, the formation carries in its lower 250 feet a graptolite and trilobite fauna characterized by *Nemagraptus gracilis* (Hall) and *Climacograptus bicornis* (Hall), a typical upper Chazyan assemblage.

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JOURNAL OF PALEONTOLOGY, VOL. 20, NO. 6, PP. 570–577, PLS. 87, 88, NOVEMBER 1946

ARENACEOUS FORAMINIFERA AND LAGENIDAE FROM THE NEOCOMIAN (LOWER CRETACEOUS) OF THE NETHERLANDS

A. TEN DAM
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ABSTRACT—Ten species of arenaceous Foraminifera and twelve species of Lagenidae are described from the Middle Neocomian (Hauterivian)—Lower Cretaceous) from the village of Glanerbrug, Overijsel Province. Twelve of these are new species, and one is a new variety.

DURING the course of a study of the Foraminifera of the Lower Cretaceous of the Netherlands, samples were collected from dark-gray clays of the Middle Neocomian (Hauterivian) exposed in the Glanerbeek near the village of Glanerbrug in the Province of Overijsel, near boundary stone No. 849, from which a rich foraminiferal fauna was obtained. Some of the more interesting forms from this locality are described.

The writer is indebted to Mr. J. Lammers for drawing the excellent illustrations.

SYSTEMATIC DESCRIPTIONS

Family AMMODISCIDAE
Subfamily AMMODISCINAE
Genus AMMODISCUS Reuss 1861
Genotype *Ammodiscus incertus* (d'Orbigny)

AMMODISCUS CRETACEUS (Reuss)
Plate 87, figure 1

Operculina cretacea Reuss, 1845, Verst. Böhm. Kreideform., vol. I, p. 35, pl. 13, fig. 64–65.
Ammodiscus cretaceus (Reuss), 1946, Schijfsma, Med. Geol. Stichting, Series C.V.Nr. 5 (in litteris).

(For references, see Schijfsma 1946)

Dimensions.—diameter 0.8 mm.

Typoid.—Geol. Stichting, Haarlem, Coll. Nr. F 876.

Remarks.—This well-known species has been recorded from the Lower and Upper Cretaceous of Europe and America. A few specimens of this species were found in the Middle Neocomian of Glanerbrug.

Genus GLOMOSPIRA Rzehak 1888
Genotype *Trochammina gordialis* Jones and Parker

GLOMOSPIRA GORDIALIS (Jones and Parker)
Plate 87, figure 2

Trochammina squam[illegible] var gordialis Jones and Parker, 1860, Geol [illegible]o. London, Quart. Journ., vol. XVI, p. 314.

(for references, see TEN DAM, Med. Geol. Stichting, Series C. V. Nr. 3, 1945, p. 77)

Dimensions.—diameter 0.3–0.8 mm.

Typoid.—Geol. Stichting, Haarlem, Coll. Nr. F 837.

Remarks.—This well-known species has been recorded from the Cretaceous, the Tertiary and Recent all over the world. Specimens of this species were fairly common in samples from the Middle Neocomian of Glanerbrug.

Family LITUOLIDAE
Subfamily HAPLOPHRAGMIINAE
Genus HAPLOPHRAGMIUM Reuss 1860
Genotype *Spirolina aequalis* Roemer

HAPLOPHRAGMIUM AEQUALE (Roemer)
Plate 87, figures 3, 4

Spirolina aequalis Roemer, 1841, Verst. d. Nordd. Kreidegeb., p. 98, pl. 15, fig. 27.
Haplophragmium aequale (Roemer), 1860, Reuss, Sitz. ber. Ak. Wiss. Wien, vol. XL, p. 128, pl. 1, fig. 2–3.
Haplophragmium aequale (Roemer), 1863, Reuss, Sitz. ber. Ak. Wiss. Wien, vol. XLVI, pp. 29–30, pl. 1, fig. 1–7.
Haplophragmium aequale (Roemer), ?1933, Eichenberg, 25[er] Jahresber. Nieders. Geol. Ver., p. 170, pl. 17, fig. 7[a–b].

not *Haplophragmium aequale* Chapman 1892
not *Haplophragmium aequale* Egger 1899
not *Haplophragmium aequale* Franke 1928

Test free, more or less elongate, oval in section. Initial portion coiled in a spire with 5 to 6 chambers visible only, in thin sections. Chambers of the spiral portion triangular, more or less irregular, increasing in size as added, slightly inflated. Uniserial portion composed of 1 to 6 chambers, almost as wide as high, inflated. Sutures more or less depressed. Last chamber tapering towards the aperture. Aperture terminal, oval and simple in the young, multiple and composed of 2 or 3 oval slits, sometimes forming an irregular aperture in the adult. Wall coarsely arenaceous, roughly finished.

Dimensions.—diameter of the spiral portion 0.65 mm. total length 1.35 mm., width of the uniserial portion 0.51 mm.

Typoid.—Geol. Stichting, Haarlem, Coll. Nr. F 860.

Remarks.—This species has been recorded from the Middle Neocomian and perhaps from the Upper Neocomian of Germany. Specimens are rather common in samples from the Middle Neocomian of Glanerbrug. Young specimens are sometimes similar to several species of the genus *Ammobaculites*, differing, however, in the oval or multiple aperture of the adult stage. The species described by Chapman (1892) as *Haplophragmium aequale* is not identical with Roemer's species because of its simple aperture and its small number of spiral chambers. Also the species described by Franke (1928) and Egger (1899) seem to belong to another species.

Genus HAPLOPHRAGMOIDES
Cushman 1910
Genotype *Nonionina canariensis*
d'Orbigny

HAPLOPHRAGMOIDES NEOCOMIANA
(Chapman)
Plate 87, figure 5

Haplophragmium neocomianum Chapman, 1894, Geol. Soc. London, Quart. Journ., vol. L, p. 695, pl. 34, fig. 2.

Test free, strongly compressed, completely involute and closely coiled. Periphery angled, more or less lobulate. Chambers indistinct, 7 to 9 in the last-formed coil. Sutures indistinct, slightly depressed near the periphery. Aperture at the base of the septal face, a narrow slit. Wall finely arenaceous.

Dimensions.—diameter 0.4 mm.

Typoid.—Geol. Stichting, Haarlem. Coll. Nr. F 893.

Remarks.—This species was recorded by Chapman from the Middle Neocomian of Surrey (England). A few specimens of this species were found in the Middle Neocomian of Glanerbrug. This species is somewhat similar to *Haplophragmoides concava* Chapman, but differs in being more compressed and in having indistinct chambers.

Genus TRIPLASIA Reuss 1854
Genotype *Triplasia murchisoni* Reuss.

TRIPLASIA GROSSERUGOSA ten Dam
n. sp.
Plate 87, figures 6a–c

Test free, elongate, triangular in section. Sides distinctly concave, angles rounded. Initial chamber globular, fairly large, followed by 2 or 3 uniserial chambers, slightly curved backward along the angles. Sutures slightly depressed, faintly curved. Aperture terminal, circular. Wall very coarsely arenaceous, rather roughly finished

Dimensions.—length 1.65 mm., width 0.85 mm., diameter of proloculum 0.4 mm.

Holotype.—Geol. Stichting, Haarlem, Coll. Nr. F 816.

Remarks.—A few specimens were found in the Middle Neocomian of Glanerbrug. This species is somewhat similar to *Triplasia roemeri* Reuss, but differs in its concave sides and in its smaller number of chambers.

Family VERNEUILINIDAE
Genus TRITAXIA Reuss 1860
Genotype *Tritaxia tricarinata* Reuss.

TRITAXIA PYRAMIDATA Reuss
Plate 87, figure 7

Tritaxia pyramidata Reuss, 1863, Akad. Wiss. Wien Sitzungsber., Band 46, p. 32, 88, pl. 1, fig. 9.

(For references see ten Dam, Geol. Mijnb. Gen., Verh, Geol. Series, Vol. XV (in litteris) and Cushman, 1937, Cushm. Lab. Foram. Research, Spec. Pub. 7, p. 22–23.)

Dimensions.—Length 0.8 mm., width 0.5 mm.

Typoid.—Geol. Stichting, Haarlem, Coll. Nr. F 815.

Remarks.—This species has been recorded from the Albian and Cenomanian of Europe. A few specimens were found in the Middle Neocomian of Glanerbrug.

Genus VERNEUILINA d'Orbigny 1840
Genotype *Verneuilina tricarinata* d'Orbigny.
BERNEUILINA CHAPMANI ten Dam n. sp.
Plate 87, figures 8a–c

Bulimina polystropha Chapman, 1894, (non Reuss), Geol. Soc. London Quart. Jour., vol. 50, p. 701, pl. 34, fig. 5.

Test free, commonly somewhat twisted, elongate, triserial, rounded at both extremities, increasing gradually rounded triangular in section, composed of 8 convolutions of 3 chambers each. Maximum width at the apertural end of the test. Initial chambers very small, increasing in size as added, in the adult slightly inflated, as wide as high. Sutures distinct, nearly horizontal, slightly depressed especially in the adult. Aperture a semicircular slit at the base of the last formed chamber. Wall arenaceous, roughly finished.

Dimensions.—Length 0.43 mm., width 0.19 mm.

Holotype.—Geol. Stichting, Haarlem, Coll. Nr. F 830.

Remarks.—This species was recorded under the name of *Bulimina polystropha* from the Middle Neocomian of England and is fairly common in samples from the Middle Neocomian of Glanerbrug. This new species is rather similar to *V. polystropha* (Reuss) from the Upper Cretaceous, differing however in its much more rounded apical end, in its chambers as high as wide, in its maximum width near the apertural end and in its less elongate last chamber. The species described by Berthelin as *Bulimina polystropha* from the Albian of the Paris Basin may represent a form transitional between our species and *V. polystropha* (Reuss). Without doubt these three species compose a special group of the genus *Verneuilina* with a very simple test.

Family VALVULINIDAE
Genus MARSSONELLA Cushman 1933
Genotype *Gaudryina oxycona* Reuss.
MARSSONELLA OXYCONA (Reuss)
Plate 87, figures 9a, b

Guadryina oxycona Reuss, 1860, Sitz. ber. Ak. Wiss. Wien, vol. XL, p. 229, pl. 12, fig. 3.

(For references, see Cushman, 1937, Cushman Lab. Foram. Research, Spec. Pub. 8, pp. 56–59.

Dimensions.—Length 1.5 mm., diameter 0.9 mm.

Typoid.—Geol. Stichting, Haarlem, Coll. Nr. F 838

Remarks.—This well known species is recorded from the Lower and Upper Cretaceous of Europe. A few specimens were found in the Middle Neocomian of Glanerbrug. Our specimens are in general smaller than the Upper Cretaceous specimens.

Family TROCHAMMINIDAE
Subfamily TROCHAMMININAE
Genus TROCHAMMINA Jones and Parker 1859
Genotype *Nautilus inflatus* Montagu.
TROCHAMMINA LIMBATA (Chapman)
Plate 87, figures 10 a, b

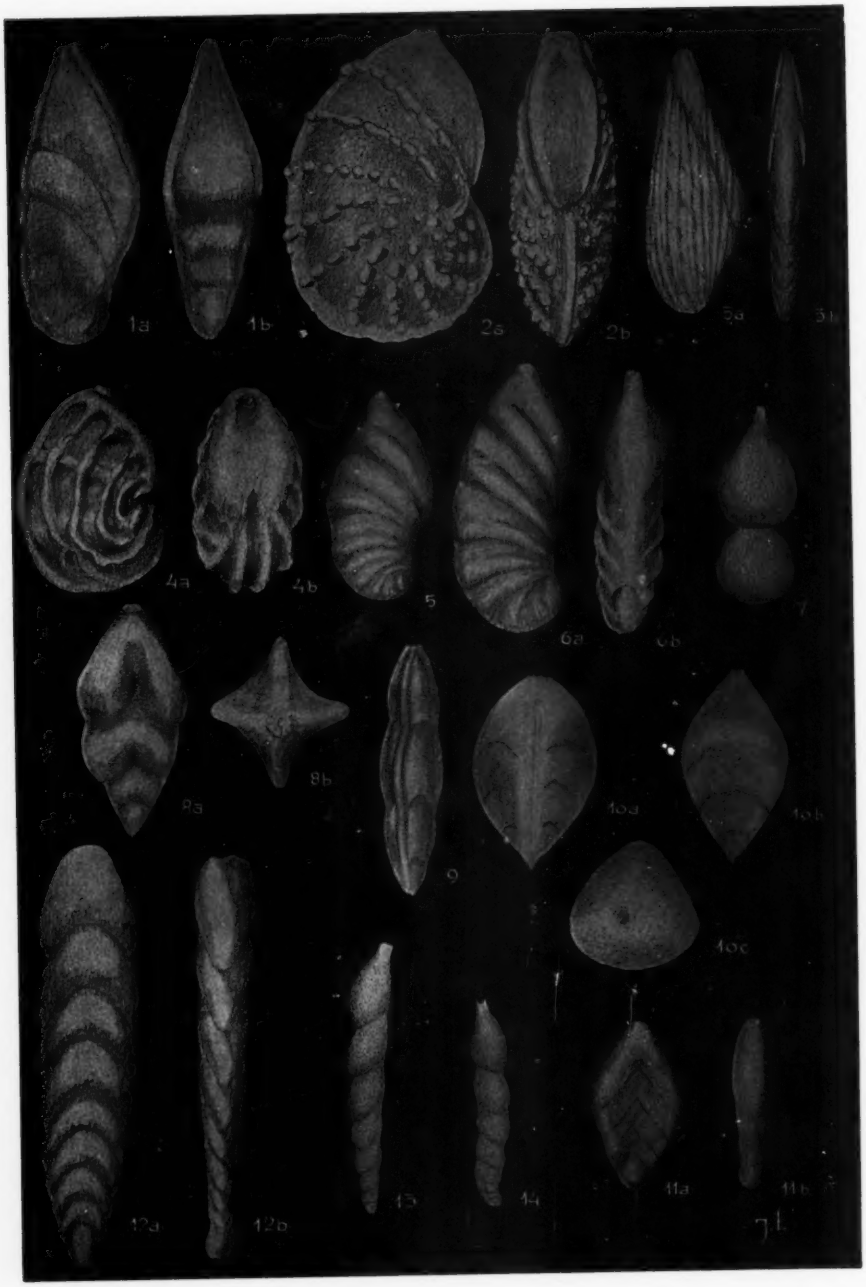
Trochammina squamata Jones and Parker, 1894, var. *limbata* Chapman, Geol. Soc. London Quart. Journ., vol. L, p. 697, pl. 34, fig. 4.

Test free, strongly compressed, concave-

EXPLANATION OF PLATE 87

FIG. *1—Ammodiscus cretaceous* (Reuss), ×36. (p. 570)
2—Glomospira gordialis (Jones and Parker), ×33. (p. 570)
3—Haplophragmium aequale (Roemer), adult, ×40. (p. 570)
4—Haplophragmium aequale (Roemer), young, ×40. (p. 570)
5—Haplophragmoides neocomiana (Chapman), ×40. (p. 571)
6a–c—Triplasia grosserugosa ten Dam, n. sp., ×30. *a*, *b*, side views, *c*, apertural view. (p. 571)
7—Tritaxia pyramidata Reuss, ×36. (p. 571)
8a–c—Verneuilina chapmani ten Dam, n. name, ×38, *a*, *b*, side views, *c*, apertural view. (p. 572)
9a, b—Marssonella oxycona (Reuss), ×21. *a*, side view, *b*, front view. (p. 572)
10a, b—Trochammina limbata (Chapman), ×100. *a*, spiral view, *b*, umbilical view. (p. 572)
11a–c—Trochammina nonionina (Reuss), ×80. *a*, umbilical view, *b*, spiral view, *c*, apertural view. (p. 573)

ten Dam, Lower Cretaceous Foraminifera



ten Dam, Lower Cretaceous Foraminifera

convex, trochoid. Periphery angled, lobulate. Spiral side convex. Chambers 6 in the last formed coil, somewhat wider than high, curved, slightly inflated. Previous coils distinct, 1½. Sutures curved backward, slightly depressed, limbate. Umbilical side slightly concave. The last chamber about twice as large as the previous one. Sutures limbate, curved, slightly depressed. Aperture a narrow slit at the base of the last chamber, on the umbilical side. Wall finely arenaceous, smoothly finished.

Dimensions.—Diameter 0.35 mm., thickness 0.08 mm.

Typoid.—Geol. Stichting, Haarlem, Coll. Nr. F 891.

Remarks.—This species has been recorded from the Middle Neocomian of England. A few specimens were found in samples from the Middle Neocomian of Glanerbrug. This species seems to be closely related to *T. squamata* Jones and Parker, but differs in its greater number of chambers in the last formed coil, in its less convex spiral side and in its less depressed, limbate sutures.

TROCHAMMINA NONIONINA (Reuss)
Plate 87, figures 11 a–c

Rotalia monionina Reuss, 1863, Akad. Wiss. Wien Sitzungsber. Band 46, p. 81, pl. 10, fig. 2.

Test free, fairly thick with rounded periphery, slightly trochoid. Spiral side only showing a very small part of a second coil. Chambers triangular, 6 or 7 in the last coil. Sutures distinct, straight, very slightly depressed. Umbilical side with a very narrow umbilicus. Chambers very slightly inflated. Sutures straight, more or less slightly depressed. Aperture semicircular, at the base of the septal face. Wall arenaceous, more or less roughly finished.

Dimensions.—Diameter 0.48 mm., thickness 0.19 mm.

Typoid.—Geol. Stichting, Haarlem, Coll. Nr. F 892.

Remarks.—This species has been recorded from the Neocomian of Germany. A few specimens were found in samples from the Middle Neocomian of Glanerbrug. From the original description of Reuss it is not clear whether this species is arenaceous, but our specimens are distinctly so and seem to be identical with the figures and description of Reuss. The aperture is characteristic of the genus *Trochammina*.

Family LAGENIDAE
Subfamily NODOSARIINAE
Genus SARACENARIA Defrance 1824
Genotype *Saracenaria italica* Defrance.

SARACENARIA FRANKEI ten Dam n. sp.
Plate 88, figures 1 a, b

Saracenaria italica Eichenberg, 1935, (non Defrance), Niedersächs. Geol. Ver. 26er, Jahresber, p. 158, pl. 11, fig. 21.

Test free, elongate, more or less like a

EXPLANATION OF PLATE 88

FIGS. *1a, b—Saracenaria frankei* ten Dam, n. sp. Holotype ×84. *a*, side view; *b*, front view. (p. 573)
2a, b—Planularia guttata ten Dam, n. sp. Holotype ×23. *a*, side view; *b*, front view (p. 574)
3a, b—Vaginulina subrotunda ten Dam, n. sp. Holotype ×40. *a*, side view; *b*, front view. (p. 574)
4a, b—Vaginulinopsis reticulosa ten Dam, n. sp. Holotype ×115. *a*, side view; *b*, front view. (p. 574)
5—Vaginulinopsis pachynota ten Dam, n. sp. Paratype ×40. (p. 575)
6a, b—Vaginulinopsis pachynota ten Dam, n. sp. Holotype ×40. *a*, side view; *b*, front view. (p. 575)
7—Nodosaria rugosa ten Dam, n. sp. Holotype ×about 50 (p. 575)
8a, b—Quadratina depressula ten Dam, n. sp. Holotype ×52. *a*, side view; *b*, apertural view. (p. 575)
9—Tristix acutangula lamellosa ten Dam, n. var. Holotype ×57. (p. 575)
10a–c—Tristix crassa ten Dam, n. sp. Holotype ×45. *a* and *b*, side views; *c*, apertural view. (p. 576)
11a, b—Frondicularia simplicissima ten Dam, n. sp. Holotype ×80. *a*, side view; *b*, edge view. (p. 576)
12a, b—Lingulina praelonga ten Dam, n. sp. Holotype ×80. *a*, side view; *b*, edge view. (p. 576)
13—Marginulina hechti ten Dam, n. sp. Paratype ×27? (Probably megalospheric specimen.) (p. 576)
14—Marginulina hechti ten Dam, n. sp. Holotype ×27. (Probably microspheric specimen.) (p. 576)

triangular prism. Initial coil low (⅓ of the total height). Periphery with a keel. Uncoiled portion well developed, triangular in section. Dorsal periphery sharply keeled. Ventral face oval, elongate, laterally angled. Initial chambers very small, 5, planispirally coiled, followed by several serial chambers, increasing in size as added, triangular, elongate, curved towards the initial spire on the ventral side. Sutures distinct, limbate, flush with the surface or very slightly depressed. Aperture terminale, radiate.

Dimensions.—Length 0.5 mm., width 0.19 mm.

Holotype.—Geol. Stichting, Haarlem, Coll. Nr F 881, paratypes: Nr. F 814.

Remarks.—This species seems closely related to the specimens described by Franke (1928) as *Cristellaria italica* (Defrance) and to *Saracenaria italica* Defrance, differing however in its spiral portion making up ⅓ of the test, in its serial chambers curved towards the initial spire on the ventral side. Our specimens are from the Middle-Neocomian of Glanerbrug. The specimens described by Eichenberg (1935) as *Saracenaria italica* from the Hauterivian of Germany seem to be identical with our species.

Genus PLANULARIA Defrance 1824
Genotype *Planularia auris* Defrance.
PLANULARIA GUTTATA ten Dam, n. sp.
Plate 88, figures 2 a, b

Test free, stout, strongly compressed, rectangular in transverse section. Periphery with a sharp central keel. Chambers numerous, up to 13 in the last whorl, low, curved. The last formed chambers show a tendency to uncoil. Umbilical region slightly depressed. Sutures distinct, curved, limbate and thickened, slightly elevated, ornamented with numerous guttiform pustules. Only the sutures of the last 2 or 3 chambers do not show this ornamentation. Apertural face truncate with a limbate rim. Young specimens show only a few sutural pustules. Aperture radiate, at the peripheral angle.

Dimensions.—Length 1.83 mm., width 1.3 mm., thickness 0.4 mm.

Holotype.—Geol. Stichting, Haarlem, Coll. Nr. F 883.

Remarks.—Specimens of this species were fairly common in samples from the Middle Neocomian of Glanerbrug. This characteristic species with its sutural ornamentation of numerous guttiform pustules is more or less related to *Cristellaria gutticosta* (Gümbel), differing, however, in its much more compressed test in the adult and its more pronounced sutural ornamentation.

Genus VAGINULINA d'Orbigny 1826
Genotype *Nautilus legumen* Linnaeus.
VAGINULINA SUBROTUNDA ten Dam, n. sp.
Plate 88, figures 3 a, b

Test free, elliptical, with a broad rounded base and a pointed, compressed top. Initial portion rounded, slightly curved. Initial chamber oval, followed by about 8 narrow chambers increasing in size as added, each following chambers more inclined towards the initial part. Dorsal periphery angled, ventral side rounded. Sutures straight, flush with the surface. Ornamentation composed of numerous, slightly diverging, longitudinal costulae. Aperture terminal radiate.

Dimensions.—Length 0.9 mm., width 0.33 mm.

Holotype.—Geol. Stichting, Haarlem, Coll. Nr. F 809.

Remarks.—This species is distinguished from related forms by its broad and rounded base and its numerous longitudinal diverging costulae. Specimens were found in the samples from the Middle Neocomian of Glanerbrug.

Genus VAGINULINOPSIS Silvestri 1904
Genotype *Vaginulinopsis inversa carinata* Silvestri.

VAGINULINOPSIS RETICULOSA ten Dam, n. sp.
Plate 88, figures 4 a, b

Test free, small, elongate, more or less oval. Periphery rounded. Dorsal side curved the same as the ventral side. Initial chambers only visible in sections, small, 5 or 6, planispirally arranged, followed by several serial chambers, wider than high, triangular, slightly curved. Sutures curved, distinct in the adult, slightly elevated. Ornamentation composed of 6 or 7 sharp, elevated longitudinal costae, curved and parallel to the dorsal side. Aperture terminal at the peripheral angle, radiate.

Dimensions.—Length 0.25 mm., width 0.15 mm.

Holotype.—Geol. Stichting, Haarlem, Coll. Nr. F 810.

Remarks.—This species is closely related to *V. d'orbignyi* (Terquem) by its reticulate ornamentation, differing however in its less elevated sutures and its more elevated longitudinal costate. A few specimens were found in the Middle Neocomian of Glanerbrug.

VAGINULINOPSIS PACHYNOTA ten Dam, n. sp.
Plate 88, figures 5, 6 a, b

Test free, elongate, laterally compressed. Periphery angled. Dorsal side curved. Initial chamber globular, followed by 3 or 4 triangular chambers, planispirally coiled, making up only half a convolution. Serial chambers triangular, wider than high, depressed, slightly inclined towards the base, especially in the adult. Terminal chamber bluntly pointed. Sutures slightly curved, oblique, limbate, elevate, thickened, especially in the median zone. Aperture terminal radiate.

Dimensions.—Length 0.85 mm., width 0.35 mm.

Holotype.—Geol. Stichting, Haarlem, Coll. Nr. F 811.

Remarks.—Specimens of this new species were fairly common in the samples from the Middle Neocomian of Glanerbrug. The species is distinguished from congeneric forms by its thickened sutures especially in the media zone of the test and its initial chambers which make up an incomplete coil.

Genus NODOSARIA Lamarck 1812
Genotype *Nautilus radicula* (Linnaeus)
NODOSARIA RUGOSA ten Dam n. sp.
Plate 88, figure 7

Dentalina sp. (? n. sp.), EICHENBERG, 1935, Nieders Geol. Ver. 26er Jahresber, p. 166, pl. 12, fig. 3.
Nodosaria sp., *Eichenberg*, ibidem, 1935, p. 172, pl. 12, fig. 4.

Test free, composed of 2 or 3 uniserial chambers. Initial chamber globular. Serial chambers 1 or 2, oval, inflated. Sutures depressed. Aperture terminal, central, at the top of the last chamber. Wall calcareous and perforate, surface roughly finished.

Dimensions.—Diameter of the proloculum 0.21 mm., length of a serial chamber 0.31 mm.

Holotype.—Geol. Stichting, Haarlem, Coll. Nr. F 841.

Remarks.—A few specimens of this species were found in the Middle Neocomian of Glanerbrug. The species differs from most others belonging to the genus *Nodosaria* in its finely roughened surface. The specimens described by Eichenberg (1935) as *Dentalina* sp. (? n. sp.) and *Nodosaria* sp. are identical with our species.

Genus QUADRATINA ten Dam 1946
Genotype *Quadratina depressula* ten Dam.
QUADRATINA DEPRESSULA ten Dam
Plate 88, figures 8 a, b

Quadratina depressula TEN DAM, 1946, Soc. Géol. France, Bull. Serie 5, vol. 16 (in litteris).

Test free, short and broad. Base bluntly pointed. Quadrangular in transverse section with sharp edges. Sides concave. Initial chamber oval, inflated, more or less pointed at the base, followed by 3 or 4 chambers curved backward along the edges, wider than high. Sutures depressed, especially at the edges, curved. Aperture circular, radiate, terminal.

Dimensions.—Length 0.6 mm., width 0.29 mm.

Holotype.—Geol. Stichting, Haarlem, Coll. Nr. F 851.

Remarks.—A few specimens were found in samples from the Middle Neocomian of Glanerbrug. The species is related to *Q. quadrata* Vieaux and *Q. maertensi* (Reuss), differing however in its more concave sides, its more depressed sutures and its small number of chambers.

Genus TRISTIX Macfadyen 1941
Genotype *Rhabdogonium liasinum* Berthelin
TRISTIX ACUTANGULA (Reuss) var. LAMELLOSA ten Dam n. var.
Plate 88, figure 9

Rhabdogonium tricarinatum Burrows, Sherborn and Bailey, (non *d'Orbigny*), 1890, Royal Micr. Soc. Journ., Sér. 2, vol. X, p. 558, pl. 10, fig. 7.

Test free, elongate, slender, triangular in transverse section. Sides concave, edges sharp, flaring. Initial chamber globular,

small, followed by several low chambers, uniserial. Stellar chambers slightly inflated, increasing little in size as added, more or less irregular. Sutures curved, slightly depressed. Aperture terminal, circular. Wall calcareous, perforate.

Dimensions.—Length 0.6 mm., width 0.19 mm.

Holotype.—Geol. Stichting, Haarlem, Coll. Nr. F 833.

Remarks. Only a very few specimens of this species were found in the Middle Neocomian of Glanerbrug. This variety differs from specimens previously described from the Hauterivian of England in its flaring edges and its less inflated chambers.

TRISTIX CRASSA ten Dam, n. sp.
Plate 88, figures 10 a–c

Test free, with pointed base, very short and broad. Distinctly triangular in section. Sides flattened, with sharp edges. Initial chamber very small, almost invisible from the outside, followed by 3 uniserial chambers, indistinct, curved backward along the edges, low. Terminal chamber with pointed top. Sutures indistinct, flush with the surface. Aperture circular, terminal. Wall calcareous and perforate.

Dimensions.—Length 0.6 mm., width 0.35 mm.

Holotype.—Geol. Stichting, Haarlem, Coll. Nr. F 813.

Remarks.—A few specimens of this species were found in the Middle Neocomian of Glanerbrug. This characteristic species is related to *T. insigne* (Reuss) but differs in its pointed base, its sutures which are flush with the surface and its general form, which is shorter and broader.

Genus FRONDICULARIA Defrance 1826
Genotype *Frondicularia complanata* Defrance.

FRONDICULARIA SIMPLICISSIMA ten Dam, n. sp.
Plate 88, figures 11a, b

Test free, small, more or less rounded rhomboidal, strongly compressed. Periphery rounded. Initial end rounded. Initial chamber small globular, followed by a series of chevron-shaped chambers, slightly inclined towards the initial end, increasing in size as added, narrow. Sutures straight, V-shaped, distinct, flush with the surface. Wall calcareous, perforate, smooth.

Dimensions.—Length 0.29 mm., width 0.18 mm.

Holotype.—Geol. Stichting, Haarlem, Coll. Nr. F 882.

Remarks.—This species is represented by only a few specimens from the Middle Neocomian of Glanerbrug. It is somewhat similar to *F. brisaeformis* Bornemann from the Liassic, differing however in its periphery without a keel and its chambers more inclined towards the initial end.

Genus LINGULINA d'Orbigny 1826
Genotype *Lingulina carinata* d'Orbigny

LINGULINA PRAELONGA ten Dam, n. sp.
Plate 88, figures 12 a, b

Frondicularia loreyi EICHENBERG, 1935 (non Berthelin), Niedersächs. Geol. Ver., Jahresber., 26, p. 179, pl. 11, fig. 1.

Test free, elongate, laterally compressed, uniserial. Periphery angled, rounded and lobulate. Initial chamber oval, inflated, relatively large, followed by a series of 8 or 9 uniserial chambers, increasing in size as added, curved, somewhat wider than high. Sutures curved, depressed. Aperture terminal, an elongate slit. Wall calcareous, perforate, smooth.

Dimensions.—Length 0.73 mm., width 0.19 mm.

Holotype.—Geol. Stichting, Haarlem, Coll. Nr. F 850.

Remarks.—A few specimens of this species were found in the Middle Neocomian of Glanerbrug. It is related to *L. furcillata* Berthelin differing however in its more elongate test, its oval and inflated initial chamber and its inflated chambers not only in the median zone. The specimens described by Eichenberg (1935) as *Frondicularia loreyi* are identical with this new species and differ from true *Frondicularia loreyi* Berthelin in their much more slender test.

Genus MARGINULINA d'Orbigny 1826
Genotype *Marginulina glabra* d'Orbigny.

MARGINULINA HECHTI ten Dam, n. sp.
Plate 88, figures 13, 14

Marginulina linearis Eichenberg, 1933 (non Reuss), Niedersächs. Geol. Ver. Jahresber., 25, p. 161, pl. 11, fig. 2, 7.

Test free, slender, elongate, oval or nearly circular in transverse section. Initial part curved with globular proloculum, small, followed by 2 or 3 small, triangular chambers. Uniserial chambers first wider than high, the last ones higher than wide, inflated, oblique, 5 to 7. Aperture circular, at the top of an eccentric neck. Wall calcareous, perforate, very finely roughened.

Dimensions.—Length 0.99 mm., width 0.2 mm.

Holotype.—Geol. Stichting, Haarlem, Coll. Nr. F 846.

Remarks.—A few specimens were found in the Middle Neocomian of Glanerbrug. The species is related to *M. linearis* Reuss differing however in its very small proluculum, its oval or circular section and its finely roughened surface.

MANUSCRIPT RECEIVED FEBRUARY 26, 1946.

JOURNAL OF PALEONTOLOGY, VOL. 20, NO. 6, P. 578, TEXT FIGS. 1–3, NOVEMBER 1946

A CAMBRIAN OSTRACODE FROM OKLAHOMA

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ABSTRACT—A new ostracode, *Leperditia harrisi*, is described from the Cambrian Honey Creek formation in Oklahoma.

INTRODUCTION

AN UNUSUAL occurrence of a leperditian ostracode was found by the writer while working on the Upper Cambrian faunas of the Arbuckle and Wichita Mountains in Oklahoma. A single left valve in a good state of preservation was discovered associated with the *Camaraspis* trilobite fauna in the Honey Creek formation in the northwestern edge of the Wichita Mountains.

Acknowledgment is due Dr. Reginald Harris formerly of the University of Oklahoma for his assistance in describing this new species.

Order OSTRACODA Latreille 1802
Family LEPERDITIIDAE Jones 1856
(restricted)
Genus LEPERDITIA Rouault 1851
LEPERDITIA HARRISI Frederickson, n. sp.
Text figures 1–3

Small leperditian form with faint retral swing; maximum dimensions through center; hingeline straight and not channeled, cardinal angles subrounded, ventral profile lowly convex, anterior and posterior noses not pronounced; overlap unobserved on single valve; surface flatly convex, posterior slope possibly shorter and more abrupt than anterior, no evidence of sulcus or eye-spot, surface apparently smooth, though possibly finely perforate in perfect preservation.

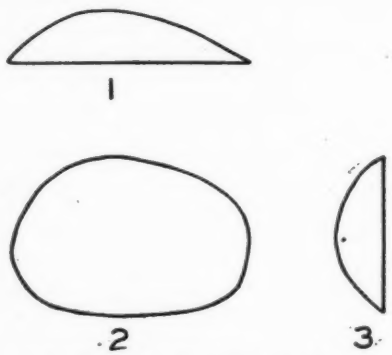
Length 2.6 mm. Height 1.8 mm. Thickness 0.5 mm. (Single valve of Holotype.)

Remarks.—This smooth species, described from a single left valve, is characterized by: (1) its small size as a representative of the genus *Leperditia* Rouault, (2) extremely flatly convex surface, (3) imperceptible retral swing, (4) rather smoothly rounded cardinal angles.

This oldest of ostracodal forms recorded from Oklahoma is apparently a true ostracode, displaying well-developed calcareous carapace rather than the chitinous covering of Cambrian Conchostraca; furthermore, the lateral outline of the specimen is typically leperiditian rather than subtrigonal, as is generally the case with Cambrian Conchostraca.

Occurrence.—Upper Cambrian, Honey Creek formation, *Camaraspis* zone. NE NE Sec. 2, 4N, 13W, Wichita Mountains, Oklahoma.

Repository.—Holotype, left valve, Okla. Geol. Mus. 105-17F-1.



FIGS. *1–3*—*Leperditia harrisi* Frederickson, n. sp. Holotype, ×12½. *1*, dorsal outline view; *2*, lateral outline view; *3*, anterior outline view.

JOURNAL OF PALEONTOLOGY, VOL. 20, NO. 6, PP. 579–590, PLS. 89, 90, NOVEMBER 1946

THE CONODONT FAUNA OF THE ORDOVICIAN DUTCHTOWN FORMATION OF MISSOURI

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ABSTRACT—The distinctive conodont fauna now known from the Dutchtown formation appears to further substantiate the validity of this stratigraphic unit as proposed by McQueen in 1937. A portion of this conodont assemblage, including 17 new species, is here described and illustrated. These conodonts are largely unrepresented in any other Ordovician fauna now known. However, it is concluded that they are probably older than the assemblage described from the Glenwood shale, distinctly younger than that of the Prairie du Chien beds, and most nearly related to the conodonts from the Joachim formation.

SEVERAL recent studies have indicated the presence of an abundant and varied conodont fauna in the Dutchtown formation of southeastern Missouri. This formation was first named and described by McQueen in 1937 who stated (1937, p. 12) that the "name Dutchtown is applied to the rocks which intervene between the St. Peter and Everton sandstones below, and the Joachim dolomite above. The name is derived from the village of Dutchtown, located in . . . Cape Girardeau County." This formation was characterized further (1937, pp. 14–15) as "comparatively pure limestones, highly argillaceous limestones, magnesian limestones, dolomites, and dolomitic sandstone." The formation also contains "fine-grained shale and siltstone, which . . . have the prevailing dark colors so characteristic of the Dutchtown formation as a whole." The Dutchtown is known chiefly from well samples together with a few surface exposures. Samples from a deep well in Cape Girardeau County indicate a maximum thickness of at least 170 feet for the formation.

As was pointed out by Cullison in 1938, the Dutchtown formation appears in a large measure to be faunally new. However, the abundance and variety of the conodonts suggest a means of identification in both surface and subsurface samples which may eventually locate Dutchtown equivalents. Representatives of the conodont genus *Multioistodus* are perhaps the most prominent element in the collection at hand, and they may prove to be reasonably distinctive of the Dutchtown. This genus is apparently not represented in the overlying and somewhat faunally related Joachim dolomite.

Although the Glenwood beds of Minnesota and adjacent areas lie directly upon the St. Peter sandstone and thus are in approximately the same stratigraphic position as the Dutchtown, the numerous conodonts described by Stauffer (1935) from the Glenwood do not seem to have many close equivalents among our specimens. In general the Dutchtown conodont fauna appears to be older than the assemblage recorded from the Glenwood shale. The Dutchtown forms are much more reminiscent of the conodonts described by Branson and Mehl from the Joachim of Missouri. Regarding the Glenwood fauna, Stauffer stated (1935, p. 129), "scarcely less remarkable is the lack of nearly all trace of the distinctive Joachim conodont fauna." The Dutchtown faunal affinities with the Joachim formation rather than with the Glenwood beds support Stauffer's distinctions between the Glenwood and Joachim conodont assemblages.

The Dutchtown conodont assemblage represents a rather early Ordovician fauna. Although it is clearly younger than that described by Furnish (1938) from the Prairie du Chien beds, the Dutchtown assemblage is probably older than the one which occurs in the Glenwood shale, and, among described Ordovician conodont faunas, it appears to be most nearly related to that of the Joachim formation.

As has been noted by Branson and Mehl, Kirk, Stauffer, and others, any large collection of conodonts usually includes several

individuals preserving basally attached material variously described as "bone-like," or as "plates." Such specimens are particularly common in Ordovician conodont faunas including that of the Dutchtown. Since the orientation and terminology of conodonts is arbitrarily established on the assumption that conodonts are teeth, the term "jaw" is used in the following descriptions to indicate this associated material.

The conodonts described in the present report were secured from an outcrop located on the north side of Missouri State highway number 74, 1.55 miles east of Dutchtown, Cape Girardeau County, Missouri. At that place there is a small concrete culvert crossing the road, and just to the north of the road there is a pasture fence. The exposure lies on the north side of the fence and about 10 feet west of the west side of the north end of the culvert. The collection was made from a small outcrop of weathered limestone and thin argillaceous limestone zones which appear to represent about the middle of the formation.

We are indebted to Professors Branson and Mehl for the helpful comments and suggestions which resulted from their critical review of our manuscript. Professor A. K. Miller has likewise generously contributed his time and editorial suggestions to this report. The photographs were retouched by Miss Mary Allen of Iowa City.

All specimens are illustrated ×40 and, unless otherwise stated in the systematic description, the outer lateral view is shown. The collection has been placed in the repository of the Geology Department of The State University of Iowa.

SYSTEMATIC PALEONTOLOGY

CARDIODUS DIMINUTIVUS Branson and Mehl? Plate 89, figure 11

(?)*Cardiodus diminutivus* BRANSON and MEHL, 1933, Missouri Univ. Studies, vol. 8, no. 2, p. 83, pl. 6, fig. 15.

(?)*Cardiodus diminutivus* BRANSON and MEHL, 1944 *in* Branson, Missouri Univ. Studies, vol. 19, no. 3, p. 69.

This is a delicate specimen consisting of a slender cusp and two equally slender denticles. The latter are incomplete on our figured specimen. The cusp is slightly excavated aborally. The cusp and denticles are discrete to the base and are slightly compressed laterally. Each contains a growth axis appearing as a light colored

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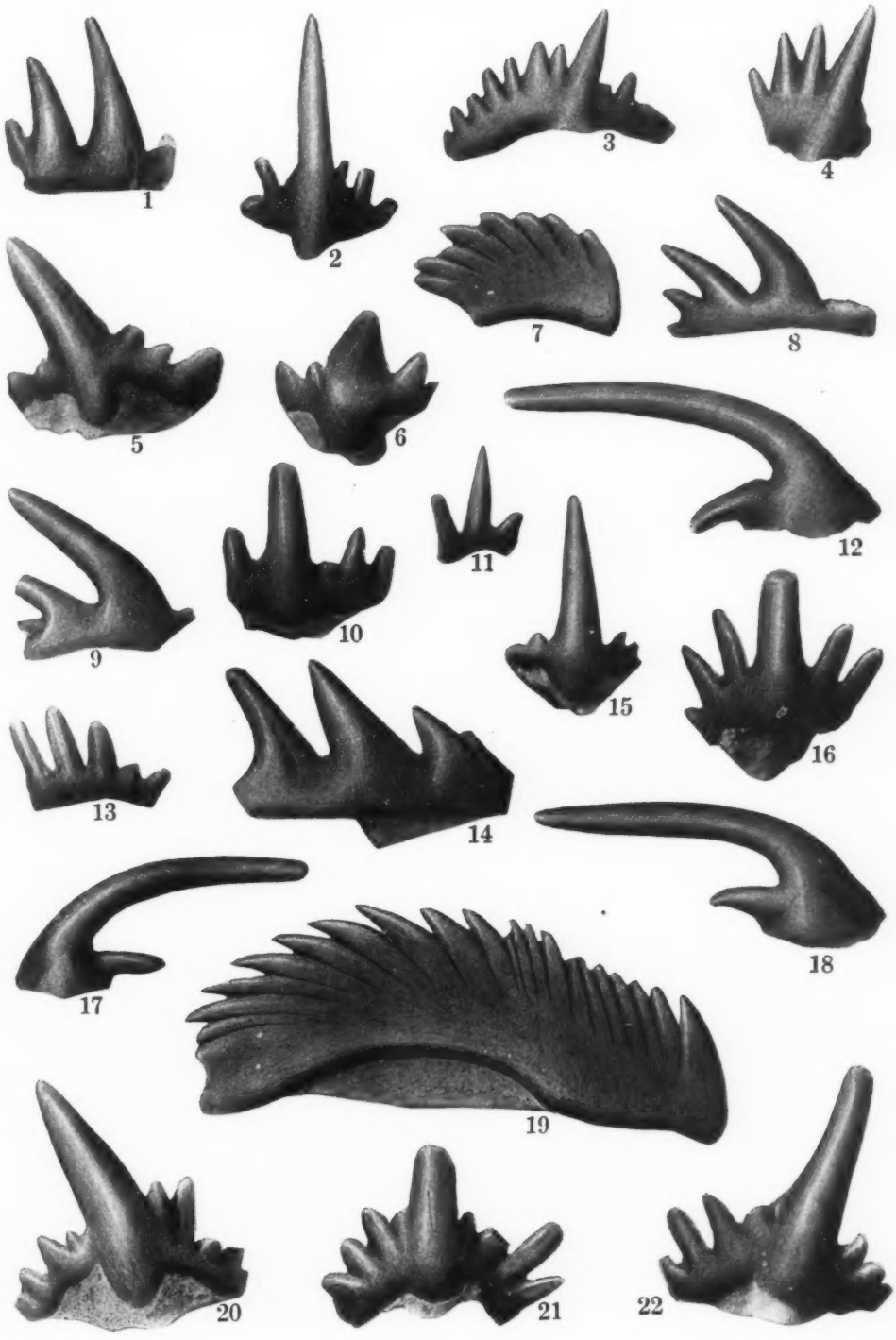
EXPLANATION OF PLATE 89

All specimens illustrated on this plate came from the Dutchtown formation 1.55 miles east of Dutchtown, Missouri, and all figures are magnified ×40. Unless otherwise stated, the outer lateral view is shown.

FIG. *1*—*Neocoleodus gracilis*, n. sp. (p. 588)
2—*Microcoelodus* cf. *M. unicornis?* Branson and Mehl. (p. 585)
3—*Ozarkodina ctenulata*, n. sp. (p. 588)
4—*Cyrtoniodus?* sp. (p. 582)
5—*Microcoelodus nodosus*, n. sp. (p. 585)
6—*Microcoelodus lobosus*, n. sp. (p. 584)
7—*Coleodus pectiniformis*, n. sp. See also figure 19. (p. 581)
8—*Polycaulodus gracilis*, n. sp. (p. 589)
9—*Polycaulodus gracilis*, n. sp. See also figure 8. (p. 589)
10—*Microcoelodus* sp. (p. 586)
11—*Cardiodus diminutivus* Branson and Mehl? (p. 580)
12—*Multioistodus subdentatus* Cullison. (p. 586)
13—*Polycaulodus*, sp. (p. 589)
14—*Neocoleodus spicatus* Branson and Mehl. (p. 588)
15—*Microcoelodus*, n. sp. (p. 586)
16—*Microcoelodus spicatus*, n. sp. (p. 585)
17—*Multioistodus subdentatus* Cullison. See also figure 12. (p. 586)
18—*Multioistodus subdentatus* Cullison. See also figures 12, 17; and plate 2, figures 2, 13. (p. 586)
19—*Coleodus pectiniformis*, n. sp. See also figure 7. (p. 581)
20—*Microcoelodus cuspus*, n. sp. (p. 583)
21—*Microcoelodus missouriensis*, n. sp. (p. 584)
22—*Microcoelodus cuspus*, n. sp. See also figure 20. (p. 583)



Youngquist and Cullison, Ordovician Conodonts

Youngquist and Cullison, Ordovician Conodonts

central "rod," which is visible particularly in the cusp when viewed with transmitted light.

Except for the presence of only two, rather than three, denticles aside from the cusp, this form agrees well in available particulars with that illustrated and described by Branson and Mehl in 1933. However, our specimen appears to be incomplete on at least one (the left) end of the bar, and the former presence of an additional denticle or denticles is strongly indicated.

Occurrence.—Dutchtown formation 1.55 miles east of Dutchtown, Missouri, and possibly in the Joachim formation, Holstein, Missouri.

Hypotype.—State Univ. Iowa, 2963.

COLEODUS PECTINIFORMIS Youngquist and Cullison,n, sp.
Plate 89, figures 7, 19

The larger of the two specimens we are referring to this species is essentially complete. Its diagnostic characteristic is considered to be the very prominent blade which is narrowly triangular in cross section, but is thickened slightly anteriorly. This blade is sharply crenulated orally by distinctly erupted denticles. These denticles are almost vertical anteriorly, but progressively posterior on the blade they curve into a horizontal plane. A narrow ridge-like thickening of the blade at the aboral margin rises to slightly less than mid-height on the blade to form an approximately symmetrical arch. The blade is narrowly excavated aborally and our large specimen clasps a section of "jaw" material in the arched portion of the blade. This material is probably not an integral part of the conodont and is distinct from the specimen, being an amber-brown hue in contrast to the deep brownish-black color of the blade proper. This particular specimen is noteworthy for its size, being 1.98 mm. in length. The smaller specimen illustrated by figure 7 on plate 89 appears to have the features of the larger form, but is fragmental and apparently preserves only a segment of the arched portion of the blade.

Occurrence.—Dutchtown formation 1.55 miles east of Dutchtown, Missouri.

Types.—State Univ. Iowa, 2964 (holotype—Pl. 89, fig. 19), 2965 (paratype—Pl. 89, fig. 7).

COLEODUS SIMPLEX Branson and Mehl
Plate 90, figures 16, 17

Coleodus simplex BRANSON and MEHL, 1933, Missouri Univ. Studies, vol. 8, no. 1, p. 24, pl. 1, figs. 22–25.

EXPLANATION OF PLATE 90

All specimens illustrated on this plate came from the Dutchtown formation 1.55 miles east of Dutchtown, Missouri, and all figures are magnified ×40. Unless otherwise stated, the outer lateral view is shown.

FIG. *1*—*Prioniodus?* sp. (p. 589)
2—*Multioistodus subdentatus* Cullison. (p. 586)
3—*Erismodus*, n. sp. (p. 582)
4—*Erismodus*, n. sp. See also figure 3. (p. 582)
5—*Pteroconus* sp. (p. 590)
6—*Microcoelodus intermedius* Branson and Mehl? (p. 583)
7—*Microcoelodus typus* Branson and Mehl. (p. 585)
8—*Ozarkodina?* sp. (p. 589)
9—*Erismodus dutchtownensis*, n. sp. (p. 582)
10—*Multioistodus tridens* Cullison. (p. 587)
11—*Multioistodus tridens* Cullison. Oral view of specimen illustrated by figure 10. (p. 587)
12—*Microcoelodus machaerodus*, n. sp. (p. 584)
13—*Multioistodus subdentatus* Cullison. Inner lateral view. See also figure 2; and plate 89, figures 12, 17, 18. (p. 586)
14—*Neocoleodus dutchtownensis*, n. sp. Inner lateral view of same specimen as figure 15. (p. 587)
15—*Neocoleodus dutchtownensis*, n. sp. See also figure 14. (p. 587)
16—*Coleodus simplex* Branson and Mehl. (p. 581)
17—*Coleodus simplex* Branson and Mehl. See also figure 16. (p. 581)
18—*Multioistodus tridens* Cullison. See also figures 10, 11. (p. 587)
19—*Neocoleodus furcatus*, n. sp. (p. 587)
20—*Ozarkodina missouriensis*, n. sp. (p. 588)

Coleodus simplex AMSDEN and MILLER, 1942, Jour. Paleontology, vol. 16, p. 303.
Coleodus simplex BRANSON and MEHL, *in* SHIMER and SHROCK, 1944, Index fossils of North America, p. 237, pl. 93, fig. 22.
Coleodus simplex MEHL and MCLAUGHLIN, *in* BRANSON, 1944, Missouri Univ. Studies, vol. 19, no. 3, p. 67, pl. 8, figs. 8–10.

Our specimens, although fragmental, seem to agree well with the form illustrated by Branson and Mehl (1933, pl. 1, fig. 23). The "narrowly triangular" shape of the blade in cross section is readily noted in our specimens, but the "deeply grooved" base is not so apparent as in the syntypes. The specimen illustrated by our figure 17 on plate 90 preserves a portion of the "jaw" base, which is broadly triangular, although somewhat rounded at the bottom, and is flattened at the apex whereon the conodont is attached. The conodont proper shows a finely "fibrous" structure and the base exhibits a similar but coarser texture.

Occurrence.—Harding sandstone of Colorado, Bighorn formation of Wyoming, and the Dutchtown formation 1.55 miles east of Dutchtown, Missouri.

Hypotype.—State Univ. Iowa, 2966 (Pl. 2, fig. 16), 2967 (Pl. 2, fig. 17).

CYRTONIODUS? sp.
Plate 89, figure 4

This well preserved specimen does not seem to agree in detail with any of the known Ordovician genera. Its bar is deep and approaches a blade-like form. The denticles show a gradation in size but are uniform in shape, being slender, moderately sharp-pointed, and elliptical in cross section. The largest denticle, or cusp, is slightly recurved posteriorly at its very tip, and all denticles and the cusp are inclined inward near their apices. The base is expanded aborally, particularly on the inner side in the area of the bottom margin of the cusp. The bar appears to be moderately excavated although the exact degree is obscured by "jaw" material which is attached. Light-colored growth axes are very prominent in our specimen, and are illustrated on plate 89, figure 4. Our form seems to most nearly approximate *Cyrtoniodus erectus* Stauffer, (1935, p. 140, pl. 9, fig. 30) but differs in the lack of an aboral cusp extension and the moderate size of the cusp relative to the denticles.

Occurrence.—Dutchtown formation 1.55 miles east of Dutchtown, Missouri.

Repository.—State Univ. Iowa, 2968.

ERISMODUS DUTCHTOWNENSIS Youngquist and Cullison, n. sp.
Plate 90, figure 9

The bar in our specimen is slightly bowed outward and moderately up-arched. Six denticles are preserved on the right limb of the bar, and three or possibly four on the left. The possible fourth denticle is confluent with the cusp, and it is not certain from either the inner or the outer view that the "denticle" is a valid unit. Except for the questionable one, all denticles are discrete to the point of entering the bar, and, although several are fractured, it appears that successive denticles on the bar are in general increasingly larger toward the cusp.

The buttress characteristic of this genus is clearly evident as an aboral extension of the cusp on the outer side, and it is also present on the inner side to an even greater degree. The outer side of the specimen is illustrated together with a portion of the "jaw" which is attached basally.

This form is similar to but does not seem to be conspecific with *Erismodus* sp. illustrated from the Dutchtown by Branson and Mehl (1944) in Shimer and Shrock, plate 93, figure 14. *E. dutchtownensis* differs in that the bar is not as acutely arched upward, and the denticles, particularly those on the right limb of the bar, are apparently more slender and relatively larger in comparison with the cusp.

Occurrence.—Dutchtown formation 1.55 miles east of Dutchtown, Missouri.

Holotype.—State Univ. Iowa, 2969.

ERISMODUS, n. sp.
Plate 90, figures 3, 4

We are referring two incomplete specimens to this genus. They apparently represent a new species but since neither conodont is complete a name is not proposed. Our best preserved individual (pl. 90, fig 3) retains one complete bar limb and the cusp, as well as a denticle fragment and a small portion of the opposite bar limb. The bar is narrowly triangular in cross section and is slightly rounded on the outer (figured) surface. The cusp is only slightly larger than the denticles but is distinguished from them

by extending aborally in the form of a process or boss which is but a little shorter than the height of the cusp above the bar. The cusp is asymmetrically situated on the bar, being inclined at an angle of approximately 45 degrees. The two bar limbs are not in the same plane either vertically or horizontally, and at their junction with the cusp form an angle on the inner side of somewhat less than 180 degrees and on the aboral side an angle of about the same size. The cusp and the denticles are essentially circular in cross section and incline inward at varying but slight amounts. The smaller specimen (pl. 90, fig. 4) apparently preserves most of one bar limb but does not include the cusp. This bar, however, is essentially a duplicate although the mirror image of the intact bar limb on the larger specimen. Both conodonts retain portions of "jaw" material to the extent that the presence or degree of aboral excavation cannot be determined.

Occurrence.—Dutchtown formation 1.55 miles east of Dutchtown, Missouri.

Repository.—State Univ. Iowa, 2970 (Pl. 90, fig. 3), 2971 (Pl. 90, fig. 4).

MICROCOELODUS CUSPUS Youngquist and Cullison, n. sp.
Plate 89, figures 20, 22

The cusp of this conodont is exceptionally prominent. It is rounded on the outer surface, is somewhat flattened on the inner surface, shows a growth axis in transmitted light, and has moderately sharp edges but only slight (if any) carinae. The bar limbs are subequal in size, the anterior limb being slightly longer. Both limbs of the bar are deflected inward and downward. The denticles on the anterior limb number about five and they encroach upon the cusp to the extent that one is partially confluent with the cusp. This cusp-confluent denticle is also partially fused with the adjacent denticle on its anterior margin. The remaining denticles on the anterior bar extension appear to be essentially discrete. The posterior bar has three or four denticles which are smaller than those of the anterior bar limb, and they are discrete from one another and do not encroach upon the cusp. The cusp extends aborally on the outer side in the form of a buttress and on the inner side it flares broadly to encompass a deep aboral excavation which extends narrowly into each bar limb. The specimens illustrated are paired individuals and each preserves a portion of the "jaw." Branson and Mehl's *Microcoelodus* sp. (1933, p. 89, pl. 7, fig. 6) appears to have the prominent cusp, the inward and downward deflection of the bar limbs, and the pronounced aboral extension of the cusp in the form of a buttress much as in our specimen. It seems probable that these two forms are closely related.

Microcoelodus is, apparently, a very useful and consequently a rather broadly applied genus. The aboral extension of the cusp in the form of a boss or process is usually not pronounced in this genus. Such forms as *M. expansus* Branson and Mehl (1933, p. 93, pl. 7, fig. 16) and our *M. spicatus* (pl. 89, fig. 16) possess this aboral cusp extension to only a moderate extent. However, others including our *M. cuspus* exhibit this feature in somewhat greater degree. In our *M. nodosus* the aboral buttress is quite prominent. This latter form partakes of many of the characteristics of the genus *Erismodus*. The apparent absence of any growth axes in *Erismodus* and the usually more prominent character of the cusp of *Microcoelodus* may be differences though some specimens of the latter genus also appear to have no growth axes. Probably these two somewhat similar genera are gradational and since no sharp line is apparent to us, we are referring the species aforementioned to *Microcoelodus*, with the acknowledgment of at least their partial resemblance to forms such as *Erismodus? dubius* and *E. symmetricus* both of Branson and Mehl, 1933. This problem of transitional forms between *Microcoelodus* and *Erismodus* was somewhat anticipated by Branson and Mehl (1943, p. 384) in the discussion of their *Microcoelodus?* sp.

Occurrence.—Dutchtown formation 1.55 miles east of Dutchtown, Missouri.

Syntypes.—State Univ. Iowa, 2972 (Pl. 89, fig. 20), 2973 (Pl. 89, fig. 22).

MICROCOELODUS INTERMEDIUS Branson and Mehl?
Plate 90, figure 6

Microcoelodus sp. BRANSON and MEHL, 1933, Missouri Univ. Studies, vol. 8, no. 2, pl. 7, fig. 6.
Microcoelodus intermedius BRANSON and MEHL, 1943, Jour. Paleontology, vol. 17, p. 384, pl. 64, figs. 38, 40, 53.

Our specimen seems to agree well with the illustrations and description of the syntypes of *M. intermedius*. The bar in our form is uparched, is slightly bowed outward, and each bar limb preserves three small denticles. In cross section, the cusp is essentially circular near the distal end, but it expands aborally on the inner surface to form a cup-like excavation in its base. This excavation, although filled with "jaw" material on our illustrated specimen, appears to be deep.

Occurrence.—Dutchtown formation 1.55 miles east of Dutchtown, Missouri, and possibly the lower Bromide of Oklahoma, and the Joachim of Missouri.

Hypotype.—State Univ. Iowa, 2974.

MICROCOELODUS LOBOSUS Youngquist and Cullison, n. sp.
Plate 89, figure 6

This conodont consists of a stout cusp mounted at a slight angle on a short bar. The cusp is approximately elliptical in cross section but is somewhat less rounded on the inner than the outer surface. The bar bears two short denticles on each limb and both the bar and the cusp appear to be deeply excavated aborally, although "jaw" material is attached making the exact degree of excavation indeterminable. The most pronounced feature of this specimen is the "hump" or rounded process which occurs at midlength on the outer surface of the bar in the area of cusp insertion. This process is roughly hemispherical though slightly flattened on the oral surface. No closely related specimen seems to have been described, but Branson and Mehl's illustration of *M. intermedius* (1943, pl. 64, fig. 40) shows a process reminiscent of this feature on our specimen.

Occurrence.—Dutchtown formation 1.55 miles east of Dutchtown, Missouri.

Holotype.—State Univ. Iowa, 2975.

MICROCOELODUS MACHAERODUS Youngquist and Cullison, n. sp.
Plate 90, figure 12

We are describing and referring three apparently complete specimens from the Dutchtown formation to this species. The cusp is the principal structure, although a bar and a single small denticle are apparent. The bar is asymmetrical, being shorter and deeper on one side of the cusp than on the other. The short side of the bar has one small but distinctly erupted denticle inclined approximately parallel to the cusp. The cusp is long and relatively stout, it is slightly curved in a direction assumed to be posterior and is also curved inward. The outer cusp surface is moderately rounded, while the inner surface is more sharply convex. The junction of these two faces form sharp ridges or carinae, which are visible from both the inner and outer sides. The bar is slightly grooved aborally, the groove being somewhat expanded beneath the cusp, but this excavation does not appear to be very deep. One of our unfigured syntypes has essentially the same form as the figured specimen, but is the mirror image of the illustrated conodont.

This species appears to be related to M. *unicornis* Branson and Mehl (1933, p. 96, pl. 6, fig. 33). Our form differs, however, in having the inner rather than the outer surface more narrowly rounded, and in possessing only one denticle adjacent to the cusp.

Occurrence.—Dutchtown formation 1.55 miles east of Dutchtown, Missouri.

Syntypes.—State Univ. Iowa, 2976 (figured syntype), 2977 (unfigured syntypes).

MICROCOELODUS MISSOURIENSIS Youngquist and Cullison, n. sp.
Plate 89, figure 21

This conodont is nearly symmetrical. The cusp is essentially median on the bar, uniformly rounded on its outer surface and apparently both long and stout (cusp is broken on all known specimens including the one illustrated). On the inner surface there is a pronounced median longitudinal carina, formed by the angular junction of the two lateral inner faces of the cusp. The bar limbs are deflected slightly inward and more prominently downward, and each limb bears four denticles the smallest of which is adjacent to, and partially confluent with the cusp. The cusp and adjacent portions of the bar are flared on the inner aboral margin and the aboral excavation is exceptionally wide and deep. Some "jaw" material is preserved in this cavity on the illustrated specimen. Growth axes are present in the larger denticles and the cusp.

Occurrence.—Dutchtown 1.55 miles east of Dutchtown, Missouri.

Holotype.—State Univ. Iowa, 2978.

MICROCOELODUS NODOSUS Youngquist and Cullison, n. sp.
Plate 89, figure 5

Bar extensions are unequal in size, with the anterior limb somewhat higher and longer. Denticles are evident as low rounded laterally compressed nodes. The anterior bar has three such denticles and the posterior bar limb has at least one. Both limbs of the bar are offset inwardly and moderately deflected downward. The posteriorly inclined cusp is gently rounded on its inner face and more pronouncedly rounded on the outer surface. Small but distinct carinae are plainly apparent on the margins of the cusp when viewed from the inner side. The cusp is produced aborally on the outer side in the form of a buttress or process. The aboral margin of the inner face of the cusp does not extend below the bar but is expanded laterally to encompass an elliptical excavation which apparently extends aborally beneath each bar limb as a narrow groove. A growth axis is evident in the cusp but the denticles are similar to the bar material and show no such axes. The illustrated specimen retains "jaw" material aborally.

Occurrence.—Dutchtown formation 1.55 miles east of Dutchtown, Missouri.

Holotype.—State Univ. Iowa, 2979.

MICROCOELODUS SPICATUS Youngquist and Cullison, n. sp.
Plate 89, figure 16

This is a subsymmetrical conodont with a conspicuous central cusp which is oval or circular in cross section. The bar extensions are approximately equal in size, are deflected inward and downward and each limb carries two or three discrete denticles which are somewhat laterally compressed. A growth axis is generally visible in the cusp and is found also in some of the denticles. The cusp is flared on its aboral inner margin and is deeply excavated. A portion of the "jaw" is retained on the illustrated specimen.

Occurrence.—Dutchtown formation 1.55 miles east of Dutchtown, Missouri.

Syntypes.—State Univ. Iowa, 2980 (figured specimen), 2981 (unfigured specimen).

MICROCOELODUS TYPUS Branson and Mehl
Plate 90, figure 7

Microcoelodus typus BRANSON and MEHL, 1933, Missouri Univ. Studies, vol. 8, no. 2, p. 90, pl. 6, figs. 31, 32.

Microcoelodus typus BRANSON and MEHL, 1943, Jour. Paleontology, vol. 17, p. 383, pl. 64, figs. 12, 36, 54–56.

Microcoelodus typus BRANSON and MEFL, *in* SHIMER and SHROCK, 1944, Index fossils of North America, p. 241, pl. 93, fig. 70.

Microcoelodus typus BRANSON and MEHL, *in* BRANSON, 1944, Missouri Univ. Studies, vol. 19, no. 3, p. 69.

The stout recurved cusp forms the predominant portion of this conodont. The bar preserves three denticles anterior to the cusp, and presumably had denticles on the posterior bar extension also, although this portion of the bar is missing from the specimen illustrated. The conodont adheres aborally and on the inward side to "jaw" material, which, if absent, would amost certainly show the base to be deeply excavated. This specimen seems to agree closely with forms well illustrated by Branson and Mehl from the lower Bromide of Oklahoma. This is apparently a long ranging species which seems to have widely occurring correlatives.

Occurrence.—Found in the Joachim formation at Warrenton, Missouri, the lower and upper Bromide of Oklahoma, and the Dutchtown formation 1.55 miles east of Dutchtown, Missouri.

Hypotype.—State Univ. Iowa, 2982.

MICROCOELODUS cf. M. UNICORNIS? Branson and Mehl
Plate 89, figure 2

Microcoelodus unicornis? BRANSON and MEHL, 1933, Missouri Univ. Studies, vol. 8, no. 2, p. 96, pl. 7, figs. 20, 24, 25.

(?) *Microcoelodus unicornis?* AMSDEN and MILLER, 1942, Jour. Paleontology, vol. 16, p. 303, pl. 41, fig. 5.

Microcoelodus unicornis? BRANSON and MEHL, 1944, *in* BRANSON, Missouri Univ. Studies, vol. 19, no. 3, p. 69, pl. 10, figs. 46, 52, 53.

The description of *M. unicornis?* by Branson and Mehl is equally applicable to our specimen, even to the presence of a clearly distinct growth axis in the cusp. In addition to the described features of the holotype, however, our specimen exhibits distinct though small carinae the length of the cusp edges.

Occurrence.—Dutchtown formation 1.55 miles east of Dutchtown, Missouri. May also occur in the Joachim formation, Holstein, Missouri, and the Bighorn formation of Wyoming.

Repository.—State Univ. Iowa, 2983.

MICROCOELODUS, n. sp.
Plate 89, figure 15

We are illustrating a single well preserved specimen which probably represents an undescribed species. It is a nearly symmetrical unit with a slender cusp which curves strongly inward just above its junction with the bar. This cusp extends aborally on the outer side as a rounded process. On the inner side it does not extend beyond the bar proper but is somewhat flared near the aboral margin. The cusp and bar limbs appear to be moderately excavated aborally but this feature is obscured by "jaw" material which is attached to the specimen. The bar limbs are small, short, and deflected inward but not downward appreciably. The denticles are small and appear to be essentially discrete to the base. They number about three on each bar limb.

Occurrence.—Dutchtown formation 1.55 miles east of Dutchtown, Missouri.

Repository.—State Univ. Iowa, 2984.

MICROCOELODUS sp.
Plate 89, figure 10

This incomplete specimen appears to be somewhat symmetrical. The cusp is approximately median on the base, uniformly rounded on both the inner and outer surfaces, and not expanded aborally appreciably on either the inner or the outer margin. Bar extensions are deflected inward but only slightly downward. The complete bar limb preserves three denticles, the fractured limb only one. These denticles are discrete to the base and exhibit growth axes as well as does the cusp. "Jaw" material is attached to the figured specimen but the aboral excavation is probably deep. Though our form is somewhat more symmetrical, affinities are evident with *M. typus* Branson and Mehl (1943, p. 383, pl. 64, fig. 36).

Occurrence.—Dutchtown formation 1.55 miles east of Dutchtown, Missouri.

Repository.—State Univ. Iowa, 2985.

MULTIOISTODUS SUBDENTATUS Cullison
Plate 89, figures 12, 17, 18;
Plate 90, figures 2, 13

Multioistodus subdentatus CULLISON, 1938, Jour. Paleontology, vol. 12, p. 226, pl. 29, figs. 13a, b.

Multioistodus subdentatus CULLISON, and MEHL and MCLAUGHLIN, *in* BRANSON, 1944, Missouri Univ. Studies, vol. 19, no. 3, p. 66, pl. 9, figs. 17–21.

Multioistodus subdentatus BRANSON and MEHL, *in* SHIMER, and SHROCK, 1944, Index fossils of North America, p. 237, pl. 93, figs. 10, 19

Several specimens showing minor variations are illustrated, and referred to *Multioistodus subdentatus*. Figure 13 on plate 90 shows the inner side of a specimen which is very close to the syntypes in that the oral carina of the cusp is particularly well developed, and flares anteriorly into the characteristic basal buttress. The stout denticle curves into essentially the same plane as the cusp. Variations of these structures can be seen on plate 89, figure 12, where the denticle is decidedly "hooked" downward, and is deflected outward at the tip. The basal buttress-like extension of the oral carina extends relatively far anteriorly but is comparatively narrow. The denticle of the specimen illustrated on plate 89, figure 17, is small and slightly "hooked" downward at the tip; in figure 18 of plate 89, the buttress is relatively large and encompasses most of the anterior portion of the base. On plate 90, figure 2, the denticle is exceptionally slender, originates close to the aboral margin of the base, and extends essentially horizontally without curving upward slightly before curving posteriorly as in all other figured specimens. All illustrations except figure 13 on plate 90 exhibit the outer side of our specimens. The unfigured inner surfaces of each of the other cusps does not show as pronounced oral carinae as in the conodont illustrated by figure 13, although they are distinctly present in all specimens. The base in most cases is partially filled with "jaw" material. However, the dark, amber-colored conodont proper offers a contrast to the lighter attached basal material, which, when properly lighted, will give some indication of the degree and shape of the basal excavation. This excavation varies considerably but is seen to be conical and reasonably deep in the specimens which we

have illustrated by figures 17 and 18 on plate 89.

Occurrence.—Dutchtown formation 1.55 miles east of Dutchtown, Missouri.

Hypotypes.—State Univ. Iowa, 2986 (Pl. 89, fig. 12), 2987 (Pl. 89, fig. 17), 2988 (Pl. 89, fig. 18), 2989 (Pl. 90, fig. 2), 2990 (Pl. 90, fig. 13).

MULTIOISTODUS TRIDENS Cullison
Plate 90, figures 10, 11, 18

Multioistodus tridens CULLISON, 1938, Jour. Paleontology, vol. 12, p. 227, pl. 29, figs. 15a, b.
Multioistodus tridens CULLISON, and MEHL and MCLAUGHLIN, *in* BRANSON, 1944, Missouri Univ. Studies, vol. 19, no. 3, p. 66, pl. 9, figs. 12, 13.

Figure 10 of plate 90 illustrates the lateral view, and figure 11, the oral view, of a specimen in which the cusp is broken slightly apicad of midlength. The oral view clearly shows the two lateral denticles and the cusp but the median denticle is hidden from view and although slightly curved laterally it is thus shown to be in approximately the same vertical plane as the cusp. The small median denticle is absent from the large specimen (Pl. 90, fig. 18), but the cusp is complete and exhibits the carinae characteristic of this species. *M. tridens* is abundant in our collection, and is also well represented by sizable individuals. e.g., plate 90, figure 18.

Occurrence.—Dutchtown formation 1.55 miles east of Dutchtown, Missouri.

Hypotypes.—State Univ. Iowa, 2991 (Pl. 90, figs. 10, 11), 2992 (Pl. 90, fig. 18).

NEOCOLEODUS DUTCHTOWNENSIS Youngquist and Cullison, n. sp.
Plate 90, figures 14, 15

The "bar" of this specimen is formed by the basal fusion of the denticles. When viewed from the outer side (pl. 90, fig. 15), this fusion is seen to be reasonably complete and the individual denticles do not crenulate the aboral "bar" margin. However, the inner side (pl. 90, fig. 14) clearly shows the distinctness of each denticle as well as the slight amount of "bar" material which joins them. The denticles curve slightly inward near their distal ends, they are stout, and are approximately elliptical in cross section. Slight grooves are visible on the outer surfaces of the denticles, and at each of the denticle edges on the inner side small carinae are apparent. Aborally the "bar" is broadly though shallowly grooved.

None of the specimens which we are assigning to the genus *Neocoleodus* appear to be particularly close to the genotype, *N. spicatus* Branson and Mehl (1933, pl. 1, fig. 37). However, our specimens do seem to be close to forms which have been referred to this genus, such as paratypes of *N. spicatus* (Branson and Mehl, 1933, pl. 1, figs. 5, 6). It should also be emphasized that the inner view of our *N. dutchtownensis* (pl. 90, fig. 14) is typical of all of our our specimens herewith referred to *Neocoleodus*, in illustrating the true nature of the basal fusion of the denticles. On the outer lateral surface the bar appears to be a valid unit, but the inner view clearly indicates that the denticles are essentially individual, and when the "bar" is viewed by means of transmitted light the slight junction of these distinct denticles becomes further apparent. Such "bars" of denticles can easily be broken into their component parts with little to indicate their once mutually formed bar-like appearance. During washing and sample-reduction the slight fusion of the denticles allows them to separate readily and consequently all of our representatives of *Neocoleodus* appear to be incomplete on either or both ends of the "bar" and the exact number of denticles in an entire specimen is uncertain.

Occurrence.—Dutchtown formation 1.55 miles east of Dutchtown, Missouri.

Types.—State Univ. Iowa, 2993 (holotype—Pl. 90, figs. 14, 15), 2994 (unfigured paratype).

NEOCOLEODUS FURCATUS Youngquist and Cullison, n. sp.
Plate 90, figure 19

Single denticles are apparently associated with bifurcated denticles in this species. The denticles are stout, curved inward at their distal ends, and essentially smooth or only slightly grooved. On the inner side slight carinae are apparent at the denticle edges. The bifurcated denticle attains the semblance of two very closely fused individuals when seen from the inner surface.

The figured specimen preserves "jaw" material such as is often associated with Dutchtown conodonts.

Occurrence.—Dutchtown formation 1.55 miles east of Dutchtown, Missouri.

Holotype.—State Univ. Iowa, 2995.

NEOCOLEODUS GRACILIS Youngquist and Cullison, n. sp.
Plate 89, figure 1

The slender denticles of this form are unique among our representatives of this genus. They are curved both inward and posteriorly to a moderate degree. Slight carinae on the edges of each denticle are visible on the inner view. This species also has its "bar" formed by the basal fusion of the cone-like denticles. The individuality of the denticles can be seen on the inner view, or from the outer view by transmitted light, the denticles proper being considerably darker than the light amber-colored material which joins them together. Aborally the "bar" is broadly excavated to a moderate depth; the outer side of the "bar" extends aborally farther than does the inner side.

Occurrence.—Dutchtown formation 1.55 miles east of Dutchtown, Missouri.

Holotype.—State Univ. Iowa, 2996.

NEOCOLEODUS SPICATUS Branson and Mehl
Plate 89, figure 14

Neocoleodus spicatus BRANSON and MEHL, 1933, Missouri Univ. Studies, vol. 8, no. 1, p. 24, pl. 1, figs. 5, 6, 37.

Neocoleodus spicatus AMSDEN and MILLER?, 1942, Jour. Paleontology, vol. 16, p. 303.

The denticles of this form are essentially elliptical in cross section though somewhat more broadly rounded on the outer than on the inner surface. Carinae are present on the denticle edges, the denticle faces are smooth or only slightly grooved, and all of the denticles incline inward and posteriorly. The "bar" is relatively stout as seen from the outer view. The illustration showing the inner view of our *N. dutchtownensis* (pl. 90, fig. 14) is also typical of the way in which the denticles of our representative of *N. spicatus* appear on the inner (unfigured) side. Some "jaw" material is attached to the specimen illustrated.

Occurrence.—Dutchtown formation 1.55 miles east of Dutchtown, Missouri, Harding sandstone of Colorado, and possibly the Bighorn formation of Wyoming.

Hypotype.—State Univ. Iowa, 2997.

OZARKODINA CTENULATA Youngquist and Cullison, n. sp.
Plate 89, figure 3

The bar is markedly compressed laterally and moderately up-arched. Its anterior limb is relatively long and deep and it is surmounted by seven denticles which are also laterally compressed. The posterior limb is shorter and not as deep as the anterior bar extension. The cusp is inclined posteriorly at a moderate angle, laterally compressed, and somewhat sharpened at the edges. The aboral margin of the cusp is somewhat flared, more pronouncedly so on the inner than on the outer side. The cusp is excavated aborally and this excavation extends as a shallow groove on the under surfaces of both bar limbs. Growth axes can be seen by transmitted light in most of the denticles and in the cusp.

We have a number of specimens which partake of the characteristics of several closely related genera. It seems likely, therefore, that the rather generalized and long ranging genus *Ozarkodina*, which has been reported from strata of Ordovician to Permian age, would best include the forms which are described here and below.

Occurrence.—Dutchtown formation 1.55 miles east of Dutchtown, Missouri.

Holotype.—State Univ. Iowa, 2998.

OZARKODINA MISSOURIENSIS Youngquist and Cullison, n. sp.
Plate 90, figure 20

Base is slightly up-arched, asymmetrical, with the end toward which the cusp is inclined being the smaller and preserving two or possibly three node-like denticles; the opposite bar limb is somewhat longer and higher, and it is laterally compressed. It carries four laterally compressed denticles that are distinctly separate apicad but near the base become confluent. The cusp is slightly elliptical in cross section and expands uniformly from tip to base becoming only slightly flared (principally on the inner side) at its aboral margin. The inner cusp face shows carinae along each edge; these ridges are not visible on the outer (figured) surface. The shorter bar limb is narrowly grooved aborally, the longer limb more broadly so. The whole specimen is in approxi-

mately the same plane vertically, neither bar limb being appreciably deflected laterally. Beneath the cusp the aboral excavation is large and it is oval in plan view, the long axis of the oval being approximately normal to the long axis of the bar.

This form embodies characteristics which are held in common by *Ozarkodina* Branson and Mehl, 1933, and *Bryantodina* Stauffer, 1935. As has been pointed out by the latter author, *Ozarkodina* is "undoubtedly related" to *Bryantodina*. We are, therefore, in this instance subscribing to the generic name *Ozarkodina*.

Occurrence.—Dutchtown formation 1.55 miles east of Dutchtown, Missouri.

Holotype.—State Univ. Iowa, 2999.

OZARKODINA? sp.
Plate 90, figure 8

Our specimen is incomplete on both bar limbs. The preserved denticles are laterally compressed and partially confluent. The cusp is somewhat more rounded but is sharp-edged and inclines in a direction assumed to be posterior. The bar limbs are unequal in height, the anterior portion being the larger. The bar thickens toward the aboral margin and is somewhat flared in the region of the aboral margin of the cusp. The cusp is deeply excavated aborally but the bar is only narrowly grooved. Stout growth axes are present in the cusp and denticles. This form appears to represent the midportion of a species of *Ozarkodina*.

Occurrence.—Dutchtown formation 1.55 miles east of Dutchtown, Missouri.

Repository.—State Univ. Iowa, 3351.

POLYCAULODUS GRACILIS Youngquist and Cullison, n. sp.
Plate 89, figures 8, 9

In cross section, the bar of this compound form is somewhat wider than high. Aborally it is essentially flat and it is not grooved. The bar's oral surface is nearly or entirely occupied by denticles which cause the bar to swell laterally as the denticles join the base. The bar is essentially straight, but may be slightly bowed outward and gently up-arched. The denticles are inclined backwards to varying degrees with the inclination becoming progressively greater posteriorly on the bar. Also, the denticles in general become shorter posteriorly on the bar, but an unfigured syntype preserves a short vertical denticle at the bar's anterior end. Denticles are somewhat sharpened on the anterior and posterior margins but they have no distinct carinae.

Occurrence.—Dutchtown formation 1.55 miles east of Dutchtown, Missouri.

Syntypes.—State Univ. Iowa, 3352 (Pl. 89, fig. 8), 3353 (Pl. 89, fig. 9), 3354 (unfigured syntype).

POLYCAULODUS sp.
Plate 89, figure 13

This compound unit has a slightly uparched bar which does not appear to be excavated aborally. In our figured specimen three denticles are preserved entire and two in part. The unbroken denticles are approximately elliptical in cross section, discrete to the base, and each shows a light colored growth axis from base to apex. The three smaller denticles rise in approximately the same plane vertically as the bar. The two larger denticles are flexed inward. On the inner side they are somewhat expanded at the base where the individuality of each denticle is more apparent than in the other denticles which are fused with the bar and individually do not persist aborally. This form is probably closely related to *P. normalis* Branson and Mehl, from the Joachim, but it appears to differ in that the denticles are not all in one plane, and the bar is somewhat smaller in proportion to the size of the denticles.

Occurrence.—Dutchtown formation 1.55 miles east of Dutchtown, Missouri.

Repository.—State Univ. Iowa, 3355.

PRIONIODUS? sp.
Plate 90, figure 1

The cusp is the predominate part of this conodont. It is curved slightly inward and is somewhat oval in cross section though possessing sharpened edges. On the inward side it is expanded basally and both the cusp and the denticle-bearing bar are somewhat excavated aborally. The anterior limb of the bar is more sharply deflected downward than is the posterior limb. The anterior limb or anticusp-like structure appears to be com-

plete on our figured specimen, and it bears no denticles. The posterior bar extension is somewhat laterally compressed and bears at least four denticles.

This form is similar to some of the many representatives of *Prioniodus* which occur abundantly in somewhat younger strata. However, the genus is not reported from the faunally related though stratigraphically higher Joachim formation, and we are therefore questionably referring our Dutchtown specimen to *Prioniodus*.

Occurrence.—Dutchtown formation 1.55 miles east of Dutchtown, Missouri.

Repository.—State Univ. Iowa, 3356.

PTEROCONUS sp.
Plate 90, figure 5

The cusp is essentially straight, comparatively slender and slightly recurved just above the base. One side of the expanded lower portion of the cusp is smooth, the other carries four distinct denticles. A slight concavity on the outer lateral (illustrated) surface is evident. The inner side of the cusp is flared near its aboral margin and a median vertical carina is present. Aborally the cusp is moderately excavated. This form somewhat resembles *P. reversus* Branson and Mehl (1933, p. 99, pl. 7, fig. 1) from the Joachim formation.

Occurrence.—Dutchtown formation 1.55 miles east of Dutchtown, Missouri.

Repository.—State Univ. Iowa, 3357.

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JOURNAL OF PALEONTOLOGY, VOL. 20, NO. 6, PP. 591–619, NOVEMBER 1946

BIBLIOGRAPHY OF FORAMINIFERA FOR THE YEAR 1945 (WITH SUPPLEMENTS FOR THE PERIOD 1936–1944)

HANS E. THALMANN
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THE FOLLOWING bibliography comprises a total of 610 titles of papers devoted partly or exclusively to Foraminifera. For the year 1945 the writer compiled 147 titles of publications which were brought to his knowledge until July 1, 1946. This date is set as the dead-line for forthcoming bibliographies of Foraminifera dealing with a preceding year.

Added to the bibliography for the year 1945 are supplements of papers published during the period 1936 to 1944. These supplements refer chiefly to the literature on Foraminifera which appeared since the outbreak of the Second World War outside of the Western Hemisphere, and were available to the writer only after cessation of hostilities. The foraminiferal papers of some countries are still inadequately covered, and, therefore, these supplements make no pretension to completeness. Collaboration in securing information regarding overlooked or missing titles will be greatly appreciated by the compiler.

Valuable help in compiling this bibliography has been received from, and cordial thanks are expressed to the following persons: Dr. J. A. Cushman and Miss Ruth Todd of the Cushman Laboratory for Foraminiferal Research in Sharon, Mass.; Dr. Brooks F. Ellis and Miss Angelina R. Messina of the Department of Micropaleontology, American Museum of Natural History, New York; Dr. H. G. Schenck, Natural Resources Section, GHQ-SCAP, Tokyo; Dr. M. Reichel, Mr. H. Benz and Mr. P. Soder of the University of Basel; Dr. R. F. Rutsch of the University of Berne; Dr. F. Brotzen of the Geological Survey, Stockholm; Mr. A. ten Dam of the Geological Foundation, Haarlem; Mr. G. Colom, Soller, Mallorca; Dr. P. J. Bermudez, Habana; Mrs. D. K. Palmer, Habana; Dr. S. R. N. Rao, University of Lucknow; Dr. T. Oinomikado, Tokyo; Dr. K. Asano, Tokyo; Dr. S. Hanzawa, Tokyo; and to the librarians of the American Museum of Natural History in New York: Miss Hazel Gay, Miss Mary V. Wissler and Mrs. T. M. Meyrer.

Of the 463 titles of papers listed in the supplements (1936–1944) 4 refer to the year 1936, one for 1937, 6 for 1938, 16 for 1939, 50 for 1940, 104 for 1941, 96 for 1942, 110 for 1943 and 76 for 1944. In previous bibliographies of Foraminifera published in this JOURNAL several papers were mentioned, which were not seen by the compiler at that time. The exact bibliographic references are, therefore, given here:

1939. LICHAREW, B. (editor): The Atlas of the leading forms of fossil fauna USSR. Vol. 6: Permian; Central Geol. and Prospecting Inst. Leningrad: Chapter on Permian system and Protozoa on pp. 5–47, with 11 text figs., 4 tables and 1 map, by B. LICHAREW. (Listed under No. 214, Jour. Paleontology, vol. 17, 1943, p. 396).

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The paper No. 98 mentioned in Journ. Paleont., vol. 18, 1944, p. 391 under PUYT, J. F. C. DE WITT, should correctly be quoted

under WITT PUYT, J. F. C. DE, and its new genera and species listed in the corresponding Index as occurring in the "Paleocene of Hercegovina" are to be placed into the Eocene.

The customary Index to new genera, species, and varieties of Foraminifera regularly published together with the bibliography has been omitted this time, because of the great amount of new forms published between 1939 and 1944. For this period alone the writer has, up to this date, on his records at least one new family, 30 new genera, 2 new subgenera, about 320 new species and nearly 100 new varieties. On record for the year 1945 are so far: 7 new superfamilies, 4 new families, 1 new subfamily, 16 new genera, 2 new subgenera, 277 new species, and 68 new varieties. They will, however, all be included in an Index to be published in an early issue of this JOURNAL during 1947.

For those workers in Foraminifera who are interested in locating new genera, species, and varieties of Foraminifera without waiting for the Index just referred to the numbers of the relevant literature is herewith given: 5, 13, 21–24, 26, 28, 32, 39, 40, 47–54, 58, 60, 82, 88, 91, 93, 94, 103–105, 111, 117, 124, 133, 136, 138, 139, 168, 213, 218, 232, 233, 235, 247, 249, 250, 254, 272, 276, 277, 282, 283, 292, 293, 323, 330, 331, 340, 345, 351, 358, 361, 367, 368, 371–373, 375, 380, 391, 394, 396, 399, 404, 410, 416, 435, 436, 442, 480, 484, 494, 530, 538, 543, 553, 556, 574, 582, 587 and 603.

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ALASKOCERAS AND THE PLECTOCERATIDAE

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ABSTRACT—The Plectoceratidae as recently redefined contain three genera so closely allied that their distinction may be considered dubious. *Alaskoceras*, added to the family by Miller and Kummel, is of uncertain position. Its gross features do not warrant its distinction from *Plectoceras*. Its siphuncle however, indicate a relationship with the Canadian Tarphyceratidae instead of the Ordovician Plectoceratidae.

STATUS OF THE PLECTOCERATIDAE

THE term Plectoceratidae as employed by Hyatt (1900) included with *Plectoceras*, Silurian and Devonian forms which Hyatt placed in *Sphyradoceras*. Foerste (1926) removed the trochoceroid species to the family Sphyradoceratidae. While this disposal no longer seems completely suitable, it will suffice for present purposes to state that the Silurian *Lechritrochoceras* and the Devonian *Sphyradoceras* are probably not closely related to each other, and that their relationship to *Plectoceras* remains as a distinct possibility, although one which requires further investigation, since the present evidence makes it equally probable that these forms were united in *Bickmorites* of the Silurian and are perhaps traceable to the Mohawkian *Centrocyrtoceras* and the Chazyan *Barrandeoceras*, while ancestors of this stock in the Canadian are highly questionable on the grounds of differing siphuncular structure.

The family Plectoceratidae was redefined by Ulrich, Foerste, Miller and Furnish (1942, p. 33) as follows: "Symmetrically coiled nautiloids in which the volutions are in contact but are not impressed dorsally. Surface of test marked by prominent transverse ribs which form deep ventral sinuses. Siphuncle ventral in position and orthochoanitic in structure. Canadian and Ordovician." It includes only *Plectoceras* Hyatt, *Metaplectoceras* Foreste and *Cycloplectoceras* Ulrich, Foerste, Miller and Furnish. It should be noted that both *Plectoceras* and *Metaplectoceras* contradict the family definition by possessing at least slight impressed zones. The family is differentiated from the coiled Tarphyceratidae where the siphuncle is also ventral, only by the ribs. These authors state "Ribs somewhat comparable to those of the Plectoceratidae are present in several other Canadian genera but they are not so strong or so regular in their development. The prominent ornamentation of the test is sufficient to distinguish members of Plectoceratidae from the closely similar Deltoceratidae." However, no mention seems to be made of any features by which the Plectoceratidae can be distinguished from the Tarphyceratidae. This family is also coiled, and also has occasional though not universal costae. Impressed zones are more persistent in the stock, but supply a poor criterion.

The Plectoceratidae, as determined from material currently identified as *P. jason* from the Chazyan of the Champlain Valley, are characterized by thin structureless connecting rings, and in this respect appear to differ from their Canadian forerunners, the Tarphyceatidae and the Canadian genera currently included in the Deltoceratidae. This criterion, which will be discussed more extensively below, seems the one feature which sets this family apart from the others.

GENERA OF THE PLECTOCERATIDAE

Much confusion seems to surround the characters of *Plectoceras* itself. The material available to me, including Chazyan specimens of Ruedemann (1906) and myself, and Billing's type of *P. jason* from the Mingan Islands, is at variance with the published description of the genus and the family based upon it. The umbilical perforation is fairly large. The whorls, in contact at the close of the first volution, are sub-

circular, but develop at once a slight impressed zone. In the Champlain specimens of *P. jason*, and also in the species described by Ruedemann as *Deltoceras vaningeni* which in my opinion is a more loosely coiled *Plectoceras*, the siphuncle is more marginal, the costae are often lost through poor preservation in the rather shaly limestones to which the species is confined, and the cross section of the shell is so distorted that precise determination of its shape is impossible, particularly in the later whorls. However, the least distorted specimens suggest that the adoral part of the phragmocone certainly loses its impressed zone quite early, which is perhaps why it has not been generally observed, and the mature living chamber becomes free (Ruedemann, 1912).

Because of the presence of the impressed zone in the early part of *P. jason*, it seemed unwise to accept Foerste's distinction between *Plectoceras* as a genus lacking involution in the Chazyan, and *Metaplectoceras* Foerste, based upon *Inachus undatus* Hall, a genus set apart from *Plectoceras* because it has an impressed zone, and which characterizes Black River and younger strata. Therefore the writer (Flower 1941, pp. 10–11) has considered it proper to reunite these genera making *Metaplectoceras* a synonym of *Plectoceras*.

Ulrich, Foerste, Miller and Furnish (1942, p. 33) described *Cycloplectoceras* based upon the new Canadian species *C. miseri*, differentiated from *Plectoceras* "in that it is smaller in size and the apical end of the shell is more tightly coiled. In typical *Plectoceras* the annulations are not developed until a relatively large size is attained by the conch." The lack of annulations in the early stages of *Plectoceras jason* is only a preservation phenomenon, as shown by my own material. The costae are well preserved in the early stages of an undescribed *Plectoceras* from the Upper Chazyan Valcour limestone of New York. *Cycloplectoceras* differs from *Plectoceras* in only one important feature, namely the tight coiling of the apex which is so developed that no umbilical perforation is apparent. The extent of the impressed zone is close to that of typical *Plectoceras* of about the same size. *Metaplectoceras* was not discussed by Ulrich, Foerste, Miller and Furnish. The species included in the genus differ from *Cycloplectoceras* in having a larger umbilical perforation, (although it is questionable whether *Cycloplectoceras funatum* may not be transitional between typical *Cycloplectoceras* and *Metaplectoceras* in this respect), probably a better impressed zone, and a cross section tending to become more specialized. It may, however, be questioned whether generic distinctions based upon such criteria have any great value.

STRUCTURE OF THE SIPHUNCLE

The writer (1941, 1942) found that in *P. (?) sewardense* the siphuncle wall is thick and complex. Comparison with thin sections of other forms revealed (1) that thin structureless rings appear to occur generally in Ordovician genera, including *Plectoceras*, *Centrocyrtoceras*, an undescribed Chazyan genus, and *Barrandeoceras*. On the other hand, many Canadian coiled cephalopods have such thick walled siphuncles that the siphuncle alone is often preserved in parts of the shell where the septa and sometimes even the shell wall have been dissolved. In most nautiloids the reverse is true, the siphuncle is destroyed in many specimens which have the septa and conch perfectly preserved. This suggests that these Canadian cephalopods have a very differently constructed siphuncle from that of their successors in Ordovician and younger strata.

Thin section study of such genera as were available for the purpose was undertaken. The results already published, (Flower, 1941, 1942) supplemented by some later observations, may be summarized as follows: The mature whorls, at least of Canadian coiled nautiloids, possess thick and complex connecting rings, sometimes composed of an inner and an outer layer, as in *P. sewardense* and *Eurystomites*, and they also have the adapical part of each ring differentiated into a structure termed the eyelet.

Comparable structures are unknown in Ordovician or younger nautilicones with the exception of a *Discoceras* described by Strand (1934, pl. 13, fig. 9). This difference suggests that the coiled cephalopods which dominated the Canadian did not give rise

to those of the Ordovician except possibly in the line of the family Trocholitidae which is differentiated from all comparable nautilicones by dorsal siphuncles. On the other hand it is also possible that Ordovician nautilicones with ventral or central siphuncles might have experienced a simplification of siphuncular structure, and might have been derived from similar Canadian genera. The possibility must also be considered, that the stock which dominated the Canadian and that which dominated the Ordovician, were initially distinct, but that some forerunners of the Ordovician stock existed in the Canadian. Precise conclusions can not be reached at present, since many of the Canadian genera are not only difficult to obtain for study, but many of the available specimens consist of internal molds replaced by chert or dolomite, and fail to show their structure clearly in thin sections. This study also showed that structures of the connecting rings of the Tarphyceratidae and of Canadian and Ordovician endoceroids are identical. Therefore the writer suggested that the Tarphyceratidae may belong to the Eurysiphonata, and they may have descended from the Ellesmeroceratidae, the forerunners of the Endoceroidea proper, although the coiled genera of the Ordovician, except for the Trocholitidae, show no indication of any relationship except with the Stenosiphonata, which are distinguished by thin structureless connecting rings. The problem is one of more than purely academic interest. Coiled cephalopods commonly occur in an exceedingly fragmentary condition in Cambro-Ordovician limestones. Such specimens often can not be determined specifically or generically with much certainty, but the siphuncles are commonly preserved. If the thick walled connecting ring in a central or ventral siphuncle is a good criterion of Canadian age, as the writer strongly suspects, the stratigrapher is thereby furnished with an extremely useful tool for age determination which can be used without generic and specific identifications which are often difficult, and in many cases cannot be made with certainty either because of distortion of the shell, difficulty in removing it from the matrix, or the incomplete nature of the specimen.

PLECTOCERAS (?) SEWARDENSE FLOWER

Miller and Kummel (1945) erected the new genus *Alaskoceras* based upon *Plectoceras (?) sewardense* Flower and referred it to the Plectoceratidae. On the basis of gross characters the separation of this species from *Plectoceras* does not seem warranted. However, the species has a siphuncle which differs from those of *Plectoceras lowi*, *P. halli* and *P. jason*, and agrees with those of the Tarphyceratidae in possessing connecting rings composed of inner and outer layers. On this basis it is believed that the species is neither a *Plectoceras* nor a member of the Plectoceratidae, but that it is allied instead to the Tarphyceratidae, and is probably Canadian rather than Ordovician in age.

The thick complex connecting rings which seemingly serve as the best criterion for the recognition of *Alaskoceras* and its distinction from *Plectoceras*, have not been recognized by Ulrich, Foerste, Miller and Furnish (1942) or by Miller and Kummel (1945). Ulrich, Foerste, Miller and Furnish treat these structures, together with some others which are either inorganic or represent calcite replacement of cameral tissues, as cameral deposits. This view is not acceptable for several reasons set forth elsewhere (Cephalopods of the Cincinnati Region, in press, Bull. Amer. Paleont.). Most important is the difference in composition between the connecting rings of Tarphyceratidae and allied forms and the true aragonitic cameral deposits which agree in structure and chemical composition with ordinary shell parts. The connecting rings of the Tarphyceratidae and Endoceroidea show, by their persistence in the face of solution of other shell parts, that they differed materially from the rest of the conch in their chemical behavior, indicating a real original difference. It is strange that Ulrich, Foerste, Miller and Furnish regarded the outer zone of the Tarphyceratidae as a cameral deposit, while an identical structure in the wall of the siphuncle of *Proterocameroceras brainerdi* (Whitfield) (see Flower, 1942, pl. 1, fig. 1, and pl. 1, figs. 3–5), was regarded by Ulrich, Foerste, Miller and Unklesbay (1944) only as a connecting ring somewhat thickened adapically.

In interpreting the structure of *Plectoceras (?) sewardense* the writer showed in a

line drawing conditions essentially identical to those found in *Eurystomites* and *Proterocameroceras*. Miller and Kummel have misinterpreted the structure completely, and have failed to recognize the outer zone of the connecting ring which is shown there lying in contact with the mural part of the septum on the venter.

The connecting rings of *Plectoceras*(?) *sewardense* are not only thick, but consist of two layers. The inner layer is dense and dark colored, and forms conspicuous segments which are faintly concave in each camera, and are not strictly tubular. Outside of this layer is another, of lighter colored material. On the venter this layer fills the entire space between the inner zone and the wall of the camera. On the dorsal side the layer is lens-shaped in section. The free parts of the septa are not well preserved in any part of the paratype, which serves as the basis of our knowledge of the interior of this species. However, in one region the septa are perfectly if rather faintly preserved ventrad of the siphuncle. Here the mural parts of the septa is well preserved. They continue to the siphuncle and terminate without the development of true septal necks. On the dorsum in the same part of the shell the tips of the septal necks may also be seen, together with a small portion of the free parts of the septa. Here also the necks are very short, although the septa are definitely bent apicad at their tips. Miller and Kummel (1945) did not see these structures and denied their existence. In the face of such a statement it is necessary to point out that the writer not only saw them himself, but succeeded in demonstrating them to his paleontological associates, Dr. K. E. Caster and Miss Helen Duncan. While these structures are rather faint, they may be brought out by a study of the opaque section when clarified by oil and a microscope cover glass.

Miller and Kummel say of the position of the siphuncle: "Flower has illustrated diagrammatically the siphuncle of the species under consideration as being distinctly removed from the ventral wall of the conch, but in his specific description he states that it 'lies in contact with the venter at least in the last (outer) whorl.' Our observations confirm his statement but not his illustration." This seemingly small difference of opinion indicates a failure to comprehend the morphology of the siphuncle. Apparently Miller and Kummel mistook the outer zone of the connecting ring for adventitious material. but it is difficult to see how this error could have been made. Part of the confusion is due to the fact that the structure of the wall of the siphuncle is best preserved in a part of the section which does not attain the exact center of the siphuncle. As a consequence the inner zone of the ring is slightly farther from the venter than it would appear in a more centrally located section.

Whether this is because the section is not quite central or because the siphuncle wobbles slightly from a purely central position is not certain, nor is it probably very important. Schindewolf has reported slight deviations of the siphuncle from a central plane in ammonoids, and the same may occur in nautiloids.

Several liberties appear to have been taken with the gross features of the morphology of the species. Miller and Kummel state that they cannot determine the size of the umbilical perforation in the species. It is difficult to see why, therefore, they have had their photograph (pl. 17, fig. 2), retouched to show about half a volution more than is clearly visible on the holotype. Likewise the retouched growth lines on the end of the penultimate whorl are exaggerated and fail to slope consistently with the coil of the shell. Differences in opinion as to whether the sutures are straight laterally or develop slight lobes are largely academic. Wherever a suture is oblique in a slightly compressed curved shell, faint lobes may be visualized by any who wish to see them.

It is difficult to see why Miller and Kummel regard this species as Early Ordovician, nor, so much as the term been abused, is their meaning in this respect entirely clear. Some authors regard the Canadian as Lower Ordovician. Others remove the Canadian as a system and leave the Chazyan as lower Ordovician, still others include both the Chazyan and Canadian under the term. The problem of the age of the species depends upon a very much larger problem already discussed, namely, whether the thick connecting rings in coiled cephalopods with ventral or subcentral siphuncles are, as the

writer suspects, a good indication of Canadian age.

In discussing the resemblance of this species to others on the basis of gross features of the shell, both the writer and Miller and Kummel have overlooked a species which is much closer to *P.*(?) *sewardense* than is any other described form. This is *Plectoceras robertsoni* (Hall) as figured by Fenton (1928), p. 139, pl. 4, 5) and listed from the "Buff limestone" of the Platteville formation at Beloit, Wisconsin, and Rockford, Ill., upper Plattin, Gabouri creek, and no. 26 of the Plattin at South Beckett Hill, Ste. Genevieve County, Mo." This species is broader and more rounded in section than *alaskense*, the free part of the shell is longer, the entire shell more slender, the lateral lobes in Fenton's figure are unequivocal, and possibly the sutures are less strongly inclined orad on the venter.

Alaskoceras was distinguished from *Plectoceras* on the basis of gross features of the shell. Miller and Kummel state that in *Plectoceras* the "whorls are expanded orad much more rapidly than are those of *Alaskoceras;* the adapical portion of the conch is loosely coiled; the living chamber of large specimens does not become markedly evolute; and the siphuncle is considerably removed from the ventral wall of the conch." Of these four differences, the first is so gradational between *Plectoceras* and *Alaskoceras* that, unless supplemented by other features emphasizing the difference, it is of little value. The loose coiling of the adapical part of the conch is more apparent than real in *Plectoceras jason* of the Mingan Islands, and specimens currently assigned to this species, the genotype of *Plectoceras*, from the Champlain Valley, have definite impressed zones in the early whorls, although the lateral aspect of typical specimens certainly suggests free whorls. Further, Ruedemann (1912) has shown that in *Plectoceras* the mature living chamber is actually free, and that involution gradually decreases in the outer whorls, the impressed zone being lost in the last whorl, the living chamber becoming free later. The siphuncle in *Plectoceras jason* is clearly more removed from the venter than in *P. alaskense* but this difference is not great. In the opinion of the writer, none of these features is sufficient to necessitate or even to make desirable the recognition of a distinct genus for *P. alaskense*. The one feature which sets the species apart strikingly from *Plectoceras*, is the thick two-layered connecting ring, a feature which Miller and Kummel either do not see or else reject.

It should also be noted that the synonomy of the species is incomplete. The original description is cited, but Miller and Kummel fail to mention that Ulrich, Foerste, Miller and Unklesbay (1944, p. 23) listed this species as *Tarphyceras ? sewardense*, without stating their reason for the change in genus.

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JOURNAL OF PALEONTOLOGY, VOL. 20, NO. 6, PP. 625–626, NOVEMBER 1946

PALEONTOLOGICAL NOTES

PERMIAN STUDIES AT THE SMITHSONIAN INSTITUTION, WASHINGTON*

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The major postwar program of the Division of Invertebrate Paleontology and Paleobotany (Department of Geology) of the Smithsonian Institution is a thorough investigation of the invertebrate faunas of the Permian Period. These studies will be based mainly on collections from the Glass Mountains, Brewster County, Texas, but loaned and borrowed material from other parts of the country will be included. The majority of the specimens to be studied are silicified and will be freed by dissolving them out of their calcareous matrix.

In announcing this program we are heralding a plan already in full swing. In the beginning it was a modest scheme to investigate levels in the Permian of the Glass Mountains in order to determine the quality of the silicification and the best localities for fossils. The success of this preliminary work led to the present intensive program. In some five years the Smithsonian Institution should have a collection of many thousands of specimens of exquisitely preserved fossils and the faunas of the Wolfcamp, Leonard and Word formations should become the best known Paleozoic assemblages of this continent. Although the solution program is supported by the Smithsonian Institution, part of the field-work was jointly sponsored by the U. S. Geological Survey and the Smithsonian Institution.

The present program was initiated in 1939 by Cooper when he and Dr. Josiah Bridge visited the Glass Mountains for five days to obtain certain brachiopods then unrepresented in the National collections. The results of this visit were so gratifying that Cooper returned to the Glass Mountains the following year. Armed with good counsel on promising localities from Dr. Philip B. King, U. S. Geological Survey, Cooper collected more than a ton of blocks. During the fall and winter of 1940 nearly all of the blocks were dissolved. Unbelievably fine specimens of most of the invertebrate phyla were obtained.

Inasmuch as the possibilities for collecting and understanding the Permian fauna seemed limitless, several specialists were invited to join the study. Accordingly, the pelecypods were referred to Dr. N. D. Newell, then at the University of Wisconsin but now of the American Museum of Natural History. Several lots of cephalopods were sent to Dr. A. K. Miller, Iowa University. The gastropods were turned over to Dr. J. Brookes Knight, then at Princeton University and now of the U. S. National Museum, who added to these a collection of similarly preserved and prepared gastropods from the Permian of the Sierra Diablo Plateau, Hudspeth-Culberson Counties, Texas, on which he was at work; the trilobites were referred to J. Marvin Weller, University of Chicago.

In the summer of 1941 Cooper and Newell joined forces under a grant from the Smithsonian Institution and spent six weeks collecting from all parts of the Glass Mountains. This expedition resulted in an accumulation of 4½ tons of blocks, of which three-quarters of a ton was sent to Newell at Madison, Wisconsin, and the remainder to Washington. Newell dissolved all of his blocks and obtained from them an incomparable collection of pelecypods and gastropods. Cooper started on the four tons but scarcely a quarter of the material was prepared before the program was sent into low gear by the war.

In the spring of 1945 Dr. R. C. Moore joined the program and took over work on the crinoids, corals and bryozoans. That summer another expedition to the Glass Mountains jointly sponsored by the Geological Survey and the Smithsonian Insti-

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tution, consisted of Moore, Knight and Cooper. This party spent six weeks accumulating some 7 tons of blocks, many of them of large size and some exceeding 100 pounds. Most of these are to be processed in the Smithsonian Institution but Moore of Lawrence, Kansas, will dissolve more than two tons of blocks collected by him.

The original work of solution was carried out in miscellaneous glassware vessels up to 5 gallons capacity. Finally a stone tub holding about 70 gallons was installed in the National Museum. This proved such a success that present plans call for increasing the facilities to three tubs. The new equipment will enable us to digest some 7 tons of blocks in four or five years.

The modest but persistent solution program carried on since 1939 has already yielded an important collection occupying some 170 trays ($22\frac{1}{2}'' \times 28\frac{1}{4}''$). Brachiopods are the most abundant fossils freed from the blocks from all parts of the Glass Mountains. These specimens are of especial importance because of their perfect preservation. Modern generic splits of the productids have been denounced by some paleontologists, but this program is yielding new evidence supporting the validity of many of them and also of additional new genera. Specimens of *Krotovia*, *Yakovlevia*, *Dictyoclostus*, *Aulosteges*, *Avonia*, *Waagenoconcha*, *Linoproductus* and "*Marginifera*" with virtually all spines in place give a new conception of these odd brachiopods. Definite information as to the living habits of these animals and the meaning of their spines has already been obtained. About 75 brachiopod genera and some 200 species occur in the collection. Knight estimates 250 new species and 100 genera, about half of them new, among the gastropods. Miller has already described many of the cephalopods taken from the blocks. The pelecypods, corals, bryozoans and sponges are equally well preserved. Chitons, trilobites, scaphopods, and remains of other groups are less abundant. Growth series of many species have been taken. By the time the solution program is completed sufficient material will have been accumulated for statistical studies of many species.

The Smithsonian program will require about five years to dissolve all blocks on hand. While the acid is simmering the men working on the individual projects will sort and study the accumulating material as follows: bryozoans, crinoids, and corals, Moore; brachiopods, Cooper; gastropods, Knight; pelecypods, Newell; cephalopods, Miller; and trilobites, Weller.

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REVIEW

GEOLOGY OF FLORIDA. By C. Wythe Cooke. (Florida Geological Survey, Geol. Bull. 29.) Tallahassee, 1945. Pp. 339; figs. 47; and geologic map.

Florida is a slightly emergent portion of the continental shelf which extends southward from the eastern United States toward the Antilles, separating the deep waters of the Atlantic from those of the Gulf of Mexico. Its highest point rises only 325 feet above the sea, and it is composed of nearly horizontal Cenozoic beds, mostly marine. The oldest exposed formation is of Upper Claiborne (Eocene) age. Structurally, Florida is a broad and very gentle arch, and, in the peninsular part, regional dips of the older exposed formations nowhere exceed about 5 feet per mile.

Many deep wells, mostly in search of oil, have been drilled since 1929, when a previous bulletin by this same title was published. They have furnished much information regarding subsurface formations. The oldest rocks penetrated are more or less metamorphosed sediments, probably of Paleozoic age, intruded by diabase believed to be Triassic. Overlying these is a known maximum of about 6,000 feet of Lower and Upper Cretaceous strata, which have been somewhat variously correlated on the basis of microfaunas. Above these are more than 2,000 feet of Paleocene and Eocene beds, which do not outcrop within the state. They are divided into several formations, some of which are correlated with well-known formations in near-by southeastern states, others of which have not been recognized in outcrop. That part of the report devoted to subsurface strata lists wells penetrating the various divisions and gives depths and notes fossils that have been identified from cuttings and cores.

Exposed formations are described much more completely, and particular details are presented county by county. The occurrences of fossils are noted, and numerous faunal lists, some of them quite extensive, are included. Environments of deposition and paleogeographic interpretations are briefly discussed for Florida and parts of neighboring states.

Exposed Tertiary beds attain a maximum composite thickness of about 1500 feet in Florida, of which the lower half is mainly limestone. Impurities, chiefly silica, increase in abundance upward, and some of the upper limestones commonly weather to secondary chert. The remainder of the stratigraphic section consists of sands, silts, clays, marls, and some limestone. Fluctuations of sea-level raised parts of Florida temporarily above the sea, and terrestrial deposits locally contain the bones of land vertebrates of both Miocene and Pliocene ages. Terrestrial mollusks and plants have also been found at a few places.

Gentle warping, such as occurred several times during the Tertiary, last occurred at the end of the Pliocene epoch; but the youngest Tertiary beds rarely dip at a rate greater than 6 inches per mile. Subsequent events of the Pleistocene epoch are recorded in a series of undisturbed elevated shorelines and related sediments. Seven shorelines have been recognized and named, which occur at elevations of from 25 to 270 feet above sea-level. Possibly an eighth, at an elevation of 5 feet, should be added.

During each of the four glacial stages, Florida is believed to have been completely emergent; but it was flooded to a greater or less degree during each of the interglacial stages, and at these times shorelines were developed. They are not described in this report, but based upon their characters, they are distinguished as "shorelines of submergence" or "shorelines of emergence."

They fall into four groups at successively lower elevations, which are correlated with the three interglacial stages and the mid-Wisconsin recessional interval. Apparently, sea-level not only fluctuated during the Pleistocene as the continental ice sheets waxed and waned but was also progressively but intermittently lowered as the result of other causes.

A series of sandy formations related to the shorelines and bearing the same names has been proposed; but, for the most part, these are thin, characterless, and poorly known. Several better-distinguished Pleistocene formations are also recognized in the southern

part of the state. They consist largely of limestone, shell beds, and marl; and each may correspond to more than one shoreline or interglacial stage, as is suggested by the interbedding of fresh-water and marine fossils.

This report is particularly important as an excellent description of the stratigraphy of Florida, and much information presented here is not available elsewhere in printed form. Data are given very completely, formation by formation; but there is no separate consideration of geologic history which includes structural movements, slight though they may have been. If one is particularly interested in this subject, pertinent facts must be gleaned from a careful study of the entire report.

Illustrations consist of 12 plates of fossils; 7 full-page maps, showing the positions of shorelines from Paleocene to late Pleistocene time; an extremely generalized and small-scale structural contour map; and numerous photographs. Because of the nature of the terrain, few of the latter have much geologic interest.

The geologic map, at a scale of 1:1,000,000, shows the distribution of twenty-three formations by two-color overprints on a black-and-white base. It requires close study because the patterns are not sufficiently distinctive to make recognition of the formations easy. It is particularly confusing because both blue and orange patterns have been used indiscriminately for formations of all ages.

J. MARVIN WELLER

ERRATA

The following correction should be made in the paper by Teng-chien Yen on Eocene nonmarine gastropods from Hot Spring County, Wyoming, volume 20, no. 5, p. 499: Explanation of figures. All indicated enlargements should be reduced one-half.

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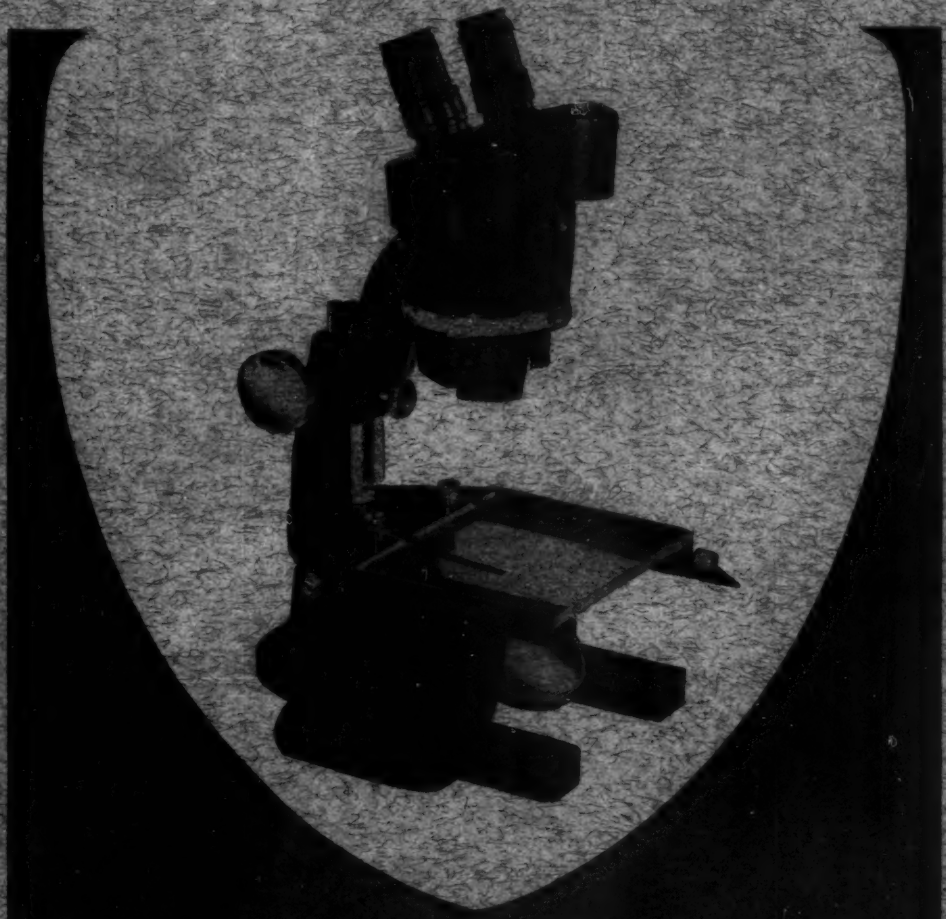

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